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SCIENTIFIC INSTRUMENTS IN RESEARCH AND INDUSTRY

THE recent Exhibition of the Physical Society is still a lively memory and it will be followed by the second British Instrument Industries' Exhibition, which is to be held at Olympia, London, during June 30–July 11. These two Exhibitions, while necessarily having a considerable amount of common ground, have essentially different backgrounds, and it is the two Exhibitions in combination which furnish a complete picture of the functions of scientific instruments at the present time and of the revolutionary changes which have taken place in those functions during the past two or three decades. While some users of instruments may feel that their interests lie entirely in the Physical Society's Exhibition and while others may feel that the British Instrument Industries' Exhibition, with its more utilitarian atmosphere, is more likely to be of value to them, yet a better spirit of understanding between the users and manufacturers of instruments might well be fostered if visitors to the recent Physical Society's Exhibition were to complement their experience by visiting the Exhibition to be held at Olympia.

In the application of science to utilitarian purposes, the use of scientific instruments has always played a major part; and it is therefore not surprising that the technological developments which have taken place during recent years in almost every sphere of human activity and endeavour have been accompanied by very drastic changes in instrument design and by a very considerable expansion of the field of instrument use. The original purpose of the founders of the Physical Society's Exhibition was to give Fellows of the Physical Society, and others interested in physics, an opportunity of seeing the current impact on instrument design of established principles of physics and of advances in physical knowledge. At that time the scientists, for the benefit of whom the Exhibition was staged, were, in fact, the main users of scientific instruments. This main purpose of the Physical Society's Exhibition still provides the guiding principle governing its organization, and although the field of use of instruments has extended far beyond the confines of the scientific world, and although the main user of instruments is no longer the man of science, yet a demonstration of the impact of scientific knowledge on instrument design is still clearly to be discerned at the Physical Society's Exhibition. On the other hand, the main purpose of the British Instrument Industries' Exhibition is to indicate the impact which the use of scientific instruments can make on the carrying out of industrial processes, on the precision of engineering and, in fact, on every department of life on which the hand of technology has been firmly placed in this present age. In other words, the Physical Society's Exhibition still, to some extent, reflects the old scientific use of instruments: the Exhibition to be held at Olympia reflects the new use of instruments, which is now far more widespread than the old.

A survey of the whole field of instrument manufacture would reveal that the accurate measurement of physical quantities is no longer the sole function of a very large proportion of instruments, although they may well be capable of making such measurements. The main function of these instruments is to utilize this property of precise measurement for some ulterior purpose; an example coming immediately to the mind is the continuous recording or control of temperature. With the conversion of instruments from measuring devices to controlling mechanisms, the border-line between instrument making and engineering has become very obscure. It is, however, still true that the most fruitful source of ideas which may eventually be incorporated in some new form of instrument is the science research laboratory; and one of the difficult problems of instrument manufacture to-day is to provide investigators in the various fields of science with the particular and peculiar instruments required by them, while at the same time meeting the demands imposed by the adoption of the scientific instrument as a major tool in industry.

It should be remarked that the research worker has himself reaped considerable advantage from the great demand which exists for instruments in the new fields of use. The character of academic research laboratories has been subject to changes no less striking than those which have occurred in the instrument and technological spheres. The urgency of research and the increased complication of the apparatus used in research have combined to limit the possibility of relying, for the building of research gear, mainly on internal mechanical resources and the skill of the researcher's hands. One characteristic of modern research laboratories is the great use made of commercial scientific instruments, and it is largely true that it is the demand for instruments from outside the scientific world which has given to the instrument industry the resources for the creation of development and research facilities, without which the almost bewildering variety of types of instruments, capable of use in so many directions, would never have been produced. To that extent the research worker has gained by the changes which have occurred in the use of instruments; but, nevertheless, the clamant demand for instruments outside the laboratory makes it difficult to produce the instruments, often of a very special character, required inside the laboratory, and presents to the instrument manufacturer a problem to which a completely satisfactory solution is difficult to find.

From the commercial point of view, it is probable that the demand of the science research worker for instruments is of less importance than the demand for instruments from utilitarian sources. Since, however, the basic raw material of scientific manufacture is scientific knowledge, it is of the highest strategic importance that the research worker should not be handicapped by having to use instruments not specially relevant to his purposes. It should be remarked that the effort given within the industry to the making of what are known as 'research instruments' is very considerable; but the problem of supplying on an economic basis instruments of a very special character for which the demand can, by the nature of the instrument, only be very small, is a very real one and demands that the maximum degree of adaptability and flexibility should be found both in the user and in the manufacturer. To this end a common knowledge of the problems of both user and producer cannot but be helpful, and certainly the British Instrument Industries' Exhibition, taken in conjunction with the Physical Society's Exhibition, should give the man of science an insight into the breadth of the commitments of the instrument industry.

TRIALS AND TRIBULATIONS OF CYTOCHEMISTRY

Cytochemistry
A Critical Approach. By Prof. J. F. Danielli. (Wiley Biological Research Series.) Pp. ix+139+12 plates. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.) 32*s*. net.

CYTOCHEMISTRY, even enzyme cytochemistry, is not as recent a development as many people seem to imagine; Nadi oxidase and Dopa oxidase reactions demonstrate that. The specific chemical delineation of cellular constituents is, in fact, more than a hundred years old, and before the development of aniline dyes investigations of this type were being actively pursued. The introduction of a vast new series of dyestuffs and the ease with which they made possible the delineation of structure led to a concentration on cell morphology and the introduction of a spurious chemical nomenclature for cell constituents, and the older work was discontinued. In the past thirty years, however, the development of new techniques, new apparatus, new chemicals and new ideas has led to a rebirth and intensification of cytochemical research. At the beginning of the Second World War the development by Gomori and by Takamatsu of a new technique for histo- and cytochemical localization of phosphorolytic enzymes led to an amazing burst of interest in, and work on phosphatase, and resulted in a spate of publications on this subject. It was fatally easy to obtain results with a technique like that for alkaline phosphatase, and it became obvious that some of the published work had been carried out by those who thought of the phosphatase reaction simply as just another cytological staining technique without appreciating the chemistry and physics of what they were doing.

In the past few years a number of workers have sought to remedy this fact and in some cases they themselves have reacted too far in the opposite direction and brought the phosphatase technique into a state of undeservedly ill repute. So far has this gone that statements have even been made that the phosphatase technique gives no indication at all of the intra-cellular distribution of the enzyme.

The time was obviously ripe for a careful and detailed consideration of this and other histochemical techniques, and the appearance of a work of this nature by J. F. Danielli is timely. His work is divided principally into four main studies: on alkaline phosphatase, on aldehydes, on proteins, and on nucleic acids. These studies are prefaced by an introductory chapter and by one on fixation, and

they are followed by a consideration of quantitative cytochemistry and a forecast of the cytochemical future.

There is no doubt that Prof. Danielli has produced a critical and balanced account which is of great value. The work in general is free of bias and all points of view are given fair treatment and comment. However, it is not surprising if the reviewer does not agree wholeheartedly with the statement on p. 2 that "A good training in histology is one of the worst backgrounds possible for cytochemical work". The same comment would apply with equal force to many other specialities, and many of the cytological contributions of biochemists make it quite obvious that a thorough study of Wilson's "The Cell in Development and Heredity" should be compulsory for them as well as for histologists, and also for others who seek to embark lightly and untrained on a voyage into a region which is fraught with the most peculiar dangers and bristles with traps for the uninitiated and the unwary. It seems likely, however, that Prof. Danielli, in making his statement, is really referring to those who think that "anyone who can cut a tissue section and make up a standard solution is competent to carry out cytochemical investigations", and if this is the case the reviewer would agree with him. He also utters a particular word of warning against the too facile acceptance of the results of differential centrifugation of cell homogenates, and although recent cytochemical results have supported some of this work such a warning at this stage is highly desirable. The discussion on the phosphatase reaction is comprehensive and critical, but the section on aldehydes, although valuable, could have been expanded with advantage. There is also, for the first time to the reviewer's knowledge, a useful evaluation of Caspersson's work—apart, of course, from those which deal with it from an optical point of view. Prof. Danielli's explanation of the significance of phosphatase for cell penetration in which he postulates that phosphatase acts as an enzymic centre of a contractile protein is most ingenious, and one looks forward to further experimental support for this idea.

From the date of the preface and from the dates of the references it is obvious that the manuscript of this work has spent an unusually long time in the press, which is a pity. Nevertheless, Prof. Danielli has produced a readable, critical work on a subject which badly needed a critical approach, and no person carrying on histo- or cyto-chemical investigation should fail to read it. GEOFFREY H. BOURNE

DESCARTES

The Scientific Work of René Descartes (1596–1650)

By Dr. J. F. Scott. Pp. x+211. (London: Taylor and Francis, Ltd., 1952.) 21*s.* net.

DESCARTES, like his contemporary Pascal, enjoys a great dual reputation, though only a few of those who study his work are aware that he has the right to more than one. An enigmatic personality, because much of his life-story is obscure, his character is rendered even more puzzling by what we know of it. Paradoxically, the man who, in the "Discours de la Méthode" and its accompanying treatises on physics, geometry and algebra, gave to the world a synthesis of scientific principles and a display of their application comparable to the great medieval compilations, was in temper and outlook far removed from both the equably minded philosopher and the modern scientist. It is perhaps understandable that he should have avoided controversy and defended his priority by making "La Géométrie" too difficult for most of his contemporaries to comprehend—a method superior to Newton's, which consisted in merely withholding publication; but it is curious, to say the least, that he could find no merit in Galileo, Fermat or Pascal, and that he invariably denied all credit to his predecessors, even when his indebtedness to them was obvious and considerable.

However, what is more relevant to an estimate of Descartes's scientific contributions is the specific point of view of their author. By the time that Descartes was composing his first great work, Renaissance thought had made its mark upon mathematics; fundamental advances in algebra were nearly a century old, and Galileo had already formulated his ideas on dynamics. Yet although Descartes may justly be described as one of the founders of modern mathematics, he is more strikingly a child of the past, and especially of the Schoolmen. Thus, while he sought for mechanical explanations of natural phenomena—and in the field of optics actually found them—his scientific procedure was rational chiefly in Whitehead's sense of the word; according to Descartes (and also to some of our contemporaries) the function of experiment is not to provide a basis for theoretical superstructure, but to confirm notions already conceived *a priori*. It can only have been by this route that Descartes arrived at his theory of vortices, which at once became enormously popular as an all-embracing explanation of the universe, and for more than a century resisted all attempts to dislodge it: as late as 1730, no less a person than Jean Bernoulli published an essay denouncing Newton's theory in its favour.

Such misjudgments in a realm where, as the history of astronomy seems to show, one man's guess is almost as good as another's, are, however, to be found in other branches of Descartes's work. Thus his treatise on analytical geometry, which initiated the modern approach to the subject, only partially aimed at reducing geometrical problems to algebraic form: Descartes was equally concerned to reverse the process, in the true spirit of the Greeks. Again, his solution of the problem of drawing a tangent to a curve—one of the foremost questions of the day—began by constructing the normal. His companion treatise on algebra, which effected great improvements in notation, suggests at the same time that the author himself was scarcely ready for all of them: although he employed literal coefficients and enunciated the rule of signs for algebraic equations, it is evident that he was even less happy with negative numbers than were some of his forerunners.

All things considered, it seems fair to say that Descartes's work has achieved importance despite the obscurantism, intentional or otherwise, of its expositor. The present account of it by Dr. J. F. Scott, who is already known for his interesting book on John Wallis, treats the subject sympathetically while not attempting any unjustifiable defence. It begins with a sketch of Descartes's life and a general survey of his work, and then proceeds to analyse each of the treatises in detail. These cover such a wide range that there is something for every scientific taste; mathematicians, in particular, will be fascinated by the descriptions of Descartes's methods in

geometry and algebra, which include a welcome account of the problem of the *locus ad quatuor lineas*, from which, it is believed, co-ordinate geometry was born.

The book is copiously illustrated; and the author has had the happy idea of including brief biographies of all the minor personalities mentioned in the text. Printing and binding are excellent. L. Roth

CRYSTALLOGRAPHICAL STRUCTURE REPORTS FOR 1949

Structure Reports for 1949

Vol. 12. General Editor: A. J. C. Wilson. (Published for the International Union of Crystallography.) Pp. viii+478. (Utrecht: A. Oosthoek's Uitgevers Mij., 1952.) 45 Dutch florins.

THE format of Vol. 11—as the prototype of the new series of "Structure Reports" published by the International Union of Crystallography—excited almost as much interest at the time of its publication as the structural data it contained, for with it there reappeared a valuable series of reference works upon which one may confidently rely.

With the appearance of Vol. 12, one can turn directly to the contents, since it was prepared by the same editors more-or-less concurrently with Vol. 11 and is strictly isomorphous with it, being strongly bound, well printed, adequately illustrated and extremely comprehensive; the arrangement within individual reports is, as before, name, formula, papers reported, unit cell, space group, atomic positions and parameters, interatomic and intermolecular distances, material, discussion, details of analysis and references. Happily the editors have been entirely successful in providing this wealth of detail without that sacrifice of clarity which makes the extraction of information from some reference books almost a kind of parlour game.

It is a striking indication of the potentialities of structural crystallography that the work reported in this volume represents the output of but a single year—a prodigious quantity even after allowance has been made for the publication of work carried on during the War, such as the investigation of penicillin and of many of the compounds of the trans-uranium elements. Current trends are everywhere discernible; for example, in the organic section, there are reports on the increasingly accurate determinations of the structure of aromatic hydrocarbons now available for comparison with quantum mechanical calculations, while in the inorganic section are some of the first-fruits of the neutron diffraction experiments, such as the structure of UH_3—a most unpromising substance for a crystallographer equipped only with X-rays. There are also reports of structure determination from single-crystal electron diffraction patterns.

One striking thing is the steady increase of symmetry from the frequently monoclinic or even triclinic crystals of organic compounds through the mainly orthogonal lattices of the inorganic section to the predominantly cubic structures of the metals section. This high symmetry is a valuable asset when one realizes how much of the work on alloys is done with powders. Occasional references to as yet unindexed patterns of high complexity remind us that a really satisfactory generalized solution of powder patterns of any symmetry is still required, in spite of some recent advances. As regards technique, however, one wonders whether the statement on p. 231, that "Absences, observed on Laue and oscillation photographs, show the above space group" ($P2_12_12_1$), indicates an unusually ingenious experimenter, or merely a tired abstractor.

The fullness of these structure reports makes the volumes particularly useful for rapid surveys of special topics in which one is currently interested—such as carbon–sulphur bond-lengths, or the frequency of polymorphism among organic crystals. Since useful ideas can be quickly substantiated in this way, and unprofitable speculations as rapidly deflated, such books are a constant challenge to review the data from some novel point of view, and thus a powerful stimulus to us all to avail ourselves of the rich diversity of experimental material now available as a starting-point for new adventures into the unknown. H. J. Grenville-Wells

STRUCTURAL LINGUISTICS

Methods in Structural Linguistics

By Zellig S. Harris. Pp. xv+384. (Chicago: University of Chicago Press; London: Cambridge University Press, 1951.) 56*s*. 6*d*. net.

THE basic concept of structural linguistics is substitutability, and the nature of the subject may be explained by the two following examples. First, in the English word *kingcup*, the two [k]-sounds are well known to be different (I write k_1ingk_2up); if, now, the philologist, interchanging them, says k_2ingk_1up to a native English speaker, he is told that the interchange is immaterial; if, however, he substitutes the initial sound of *man* for k_1, producing $mingk_2up$, he is told that the interchange is not immaterial (for a *Ming cup* is not a *kingcup*). By this procedure the philologist has learnt that there is an essential difference between the distinction k_1/k_2 and the distinction k_1/m; he therefore makes one 'phoneme' [k], materializing in at least two forms k_1 and k_2, and another, different phoneme [m]. Secondly, the informant will allow the substitution of *from* for *to* and will not allow that of *dog* for *to* in the phoneme-block *Come to London*; in this way the philologist learns that *to* and *from* are 'morphemes' of the same kind and that *dog* is a different kind of morpheme from *to*.

Prof. Z. S. Harris's long and complicated book is essentially devoted to the problems indicated by the above two examples. He describes how the phonemes and morphemes of a language may be set up by the sole aid of a native informant (as an example of the first procedure, he sets up the phonemes of Swahili). His account of the concepts and methods is entirely lucid; regrettably, the book lacks an index of authors cited—were such an index made, many philologists might feel that it contained an undue proportion of American names.

Structural linguistics appears, rather refreshingly, to have little theory underlying it; it is a purely practical discipline, and it therefore stands or falls solely according to whether it does or does not accomplish what it purports to—that is, to extract the phonemes and morphemes of a hitherto unstudied language. With regard to phonemes, the 'cross-word puzzle' method which Mr. J. Josephs and I advocate[1] is undoubtedly greatly superior to the structural-

linguistic method, but our method suffers from the grave disadvantage that it can only be applied to languages which possess at least one speaker who appreciates, or who can be trained to appreciate, the nature of the concept 'phoneme'; of the world's languages, approximately ten thousand in number, perhaps not more than five hundred possess such a speaker. The structural-linguistic method depends entirely upon getting the 'right' response to a substitution from a native informant; presumably, the latter can make three different responses: 'immaterial' (*k_2ingk_1up* for *k_1ingk_2up*); 'not permissible' (*$hingk_2up$* for *k_1ingk_2up*)—[k] and [h] are different phonemes in English; and, 'it alters the meaning' (*Ming cup* for *kingcup*). Can we really be sure that native informants will always distinguish clearly between these three responses? The structural-linguistic method *could* be tested against the cross-word puzzle method (though, so far as I know, it has not yet been); Lappish, with its highly complex phoneme-system, would be an excellent language for the test; we could use the structural-linguistic method on a 'primitive' kind of Lapp and see if the results agreed with those obtained, on the cross-word puzzle method, by a Lapp of, say, Ph.D. standard (at least one such exists).

ALAN S. C. ROSS

[1] Josephs, J., and Ross, A. S. C., "Triangular Tables for the Phonemes of English", *Archivum Linguisticum*, **1**, 41 (1949).

FLORA AND VEGETATION OF IRELAND

Die Pflanzenwelt Irlands (The Flora and Vegetation of Ireland)

Ergebnisse der 9 Internationalen Pflanzengeographischen Exkursion durch Irland 1949. Redigiert von Werner Lüdi. (Veröffentlichungen des Geobotanischen Institutes Rübel in Zürich, Heft 25.) Pp. 421. (Bern: Hans Huber, 1952.) 26.50 francs.

THE International Phytogeographical Excursion of 1949, held in Ireland under the leadership of Prof. D. A. Webb and Mr. G. F. Mitchell, was attended by twenty-three botanists of some twelve different nationalities, and was the ninth of a series of meetings of specialists in plant ecology which have done much to promote international understanding in a field where opinions tend more than usually to differ.

The present volume begins with a narrative of the Excursion and a report on the "Second Conference of Pollen Workers" which took place afterwards in Dublin; these are followed by short but authoritative accounts of Irish geology and the Irish flora, by Mr. Mitchell and Prof. Webb respectively, then by ten original contributions by K. Jessen, Max Welten, J. Heslop-Harrison, I. Markgraf-Dannenberg, F. Markgraf, H. Gams, F. Firbas, J. Braun-Blanquet, R. Tüxen and W. Lüdi (who edited the whole volume).

Among the topics dealt with are the pollen analysis of Irish peat, Irish dactyloid orchids, oceanic bryophytes and Irish woodlands. In an interesting account of Irish *Festuca* races, I. Markgraf-Dannenberg records an interesting addition to Ireland's Mediterranean flora, *F. ovina* ssp. *indigesta* (Boiss.) Hack., previously known only from the French Pyrenees and the Iberian Peninsula. In another paper Dr. Braun-Blanquet refers to a distinct race of *Antennaria dioica* found on the Irish eskers, which he has described elsewhere as *A. hibernica*.

Dr. Lüdi has some interesting comments to make on the different habitats, in Switzerland and Ireland respectively, of *Empetrum nigrum*, *Calluna*, *Sedum roseum* and other plants. In an article mainly concerned with the well-known problem of the occurrence of the usually basiphilous *Schœnus nigricans* in ombrogenous Irish bogs, Prof. Firbas refers to the view, originally proposed by Nilsson-Ehle, that the xeromorphy of bog plants is related to mineral starvation rather than to water shortage.

The history of the Irish flora is a constantly recurring theme in many of the contributions. Dr. Jessen, in a paper summarizing his own researches on the late Quaternary deposits, points out that in Zone III of the Late Glacial, Ireland was to the north of the polar timber line; nevertheless he thinks it possible that the American and most of the Lusitanian species (except woodland plants such as *Arbutus*) may have been able to survive the last glaciation in favourable places, an opinion with which several other contributors seem to agree.

By far the longest chapter in the book is the description by Dr. Braun-Blanquet and Dr. Tüxen of the plant communities met with during the Excursion. Since a very representative fraction of Ireland was traversed, almost every plant community above the tide-mark is dealt with. This contribution will be greatly appreciated by British ecologists, since communities with which they are familiar (those of Ireland being in the main similar to those of Great Britain) are classified here according to Dr. Braun-Blanquet's well-known system; thus for the first time we have an excellent basis for forming an opinion on its much-debated merits. It is impossible to discuss this question here, but it is perhaps worth directing attention to the extreme artificiality of a scheme which names one of its major divisions ('*Potentilletalia caulescentis*') after a species which does not occur within some seven hundred miles of Ireland, and divides into several widely separated categories the communities which are normally found successionally connected and spatially contiguous on sand-dunes. On the other hand, it must be freely admitted that Dr. Braun-Blanquet's clear and methodical procedure represents something still missing in British ecology. May we hope that a method of classifying vegetation may yet be developed which will retain this desirable feature without the artificiality?

British ecology has been insular for too long, and in Britain we have much to gain by realizing that our plant communities are for the most part impoverished versions of those better and more extensively developed on the Continent. It is as a help towards this end that this report of the Excursion is valuable, and we may be particularly grateful for the comparisons with France, Spain and other countries which the unrivalled experience of Dr. Braun-Blanquet and Dr. Tüxen enables them to make. Naturally, the hurried impressions of three weeks are not always accurate: several contributors stress as peculiarly Irish features which are equally well displayed in western Scotland and Wales—for example, it is not only in Ireland that the two species of *Hymenophyllum* grow together. Nevertheless, the British ecologist will be grateful to the contributors to this volume, for helping him to see his own vegetation as others see it.

P. W. RICHARDS

THE ROYAL BOTANIC GARDENS, KEW

CENTENARY OF THE HERBARIUM AND LIBRARY

THE modern history of Kew began in 1841 when the Royal Gardens became a government institution and William Jackson Hooker, professor of botany in the University of Glasgow, was appointed director. There was then neither herbarium nor library at Kew and the new director brought with him his own collections and books. In 1853 Miss E. Bromfield presented to Kew the Herbarium and Library of her late brother, Dr. W. Arnold Bromfield, and these formed the nucleus of the present Herbarium and Library. In 1854 George Bentham gave his valuable collections to be added to the Bromfield Herbarium and Library, and in 1866 the Government purchased the private collections of Sir W. J. Hooker. The Bentham and Hooker Herbaria, together with new collections that quickly began to be sent to Kew, led to the rapid growth in size and importance of the preserved botanical collections and the essential library. To these early donors or collectors Kew owes a double debt: the richness of the Herbarium in early types and the complete runs of many valuable periodicals in the Library. In addition, the Hookers and Bentham, by the excellence and number of their published researches, made Kew the world centre of botanical, and especially of botanical systematic, studies. The Herbarium now contains some six million 'specimens' and the Library more than fifty thousand volumes.

Since it was in 1853 that the Bromfield collections were presented, it is appropriate that the centenary of the Herbarium and Library at Kew should be celebrated in 1953. To mark the occasion an exhibition of specimens, books, manuscripts, diagrams, photographs, drawings, etc., was arranged in the three wings of the Herbarium and in the Library. Official guests, individual scientists, university students, and members of many scientific societies visited the exhibition during the period May 7–9. The theme of the exhibition was the research carried out at Kew during the past hundred years, and particularly that in connexion with the systematics of plants. About fifty separate but interconnected series of exhibits, some of them extensive, were staged by members of the staff, who ably demonstrated their special subjects.

The early period of Kew, and of the Herbarium and Library in particular, was illustrated by photographs, plans, drawings, and original items of historical interest. The unbroken sequence of administration could be followed through the periods of directors from Sir W. J. Hooker to the present director, Sir E. J. Salisbury, and of keepers from Prof. Daniel Oliver to the present keeper, Dr. W. B. Turrill. It was clearly shown that, in addition to carrying the burden of administration, now greatly increased, both the directors and keepers contributed considerably to botanical knowledge by their own researches.

The work of the Herbarium is divided into departments on a double basis, purely systematic and phytogeographical. The systematic divisions were well illustrated by the work done at Kew on the cryptogams. Collections of Algæ dating from the voyages of H.M.S. *Erebus and Terror* and of H.M.S. *Challenger* were on view as well as those used by well-known algologists. The taxonomy of fungi has received much attention at Kew during the past century, and the collections and work of Cooke, Massee, Wakefield, and others attract many mycologists to study, often for long periods, in the Herbarium. Selections from types of W. J. Hooker to recent additions illustrated the rich material of liverworts and mosses preserved in the Herbarium and now being revised. The pioneer investigations of W. J. Hooker and J. G. Baker on the ferns and fern allies greatly enriched Kew in type specimens. Examples of their materials and the results of their researches were contrasted with a fine collection of living plants of twenty-six genera of ferns recently gathered in Ceylon and now being grown at Kew. This was only one of many exhibits showing the facilities existing, and utilized, at Kew for linking together the study of living plants with the examination and comparison of numerous preserved specimens of diverse origins.

There are at Kew specialists for the orchids and grasses, but most of the work carried out on the seed-bearing plants is divided on a geographical basis. Monographic studies have not been neglected; but, partly because of the need for development of what are now Dominions, Colonies, or Protectorates, a major item in the policy at Kew has been, and still is, to prepare Floras of areas usually with political boundaries. These sometimes coincide closely with phytogeographical divisions, but are sometimes more or less artificial. The practical advantages of having accounts complete to date of publication, with descriptions, keys to determination of taxa, summaries of known range and distribution, etc., for this or that portion of the Commonwealth, needs no emphasis. Their preparation should naturally be a British enterprise and, moreover, involves no competition with either the preparation of floras for other parts of the earth's surface or with that of systematic monographs such as those of the "Pflanzenreich".

In preparing the centenary exhibition, members of the staff had a wealth of material from which to select subjects to illustrate the contributions of their predecessors and themselves to floristic research. A tabulation based on a map of the world listed forty-one Floras prepared entirely or largely at Kew. These ranged from single volumes, as those of Bentham and Hooker "Handbook of the British Flora", or the "Flora Simlensis", to the many volumes of the "Flora of British India" or the "Flora of Tropical Africa". A complete survey of the floristic and phytogeographical interests of past and present members of the Kew staff, and of other botanists who have carried out much of their work at Kew, would occupy much space, and here only a brief account of some of the collections and of work published as a result of investigations conducted at or in connexion with Kew can be given. Since the time of Bentham and Hooker, many members of the Herbarium staff have carried out field studies on the British flora as a recreation, mainly concentrating on a few special families such as those of the orchids, sedges, and grasses or detailed investigations of smaller groups. The Herbarium, in fact, contains valuable special collections of British plants such as

those of Bromfield, Lightfoot, Borrer, and Watson. It happens that three or four species new to the British flora have quite recently been first recorded from material sent or brought to Kew. Specimens of these were exhibited. The flora of Europe and the Orient (Nearer East) is well represented in the collections, and researches, especially on the plant life of the Balkan Peninsula and Cyprus, have been published in book form and in series of papers. The rich harvest of plants from China garnered by Henry, Wilson and other famous collectors must be consulted by students of plants of the Far East, and its importance is enhanced by the many species introduced into horticulture. The "Index Floræ Sinensis" is based almost entirely on material at Kew. The service of J. D. Hooker to our knowledge of Indian plants must always be acknowledged since it culminated in the classic "Flora of British India". This was followed by the publication of a series of more local floras, many of which were prepared at Kew. The plants of Siam were largely worked out by a former member of the Kew staff, and the "Flora of the Malay Peninsula" is indissolubly linked with Kew.

The greater part of the continent of Africa has been covered botanically by Kew publications, including the "Flora of Tropical Africa", the "Flora Capensis", the "Flora of West Tropical Africa" (now under revision), Hooker and Ball's work on Morocco, and numerous other books and papers. Publication of the "Flora of Tropical East Africa" has recently begun. Exhibits connected with these and other floristic researches consisted of dried specimens, living plants (many illustrating special morphological features or peculiar physiological behaviour), statistical tables, drawings and paintings, methods of collecting, and of printed books and papers.

Bentham's "Flora Australiensis" and J. D. Hooker's Floras of the southern hemisphere together form the foundation of all subsequent studies of the flora of Australasia. Much of the later floristic research has been carried out by Australian and New Zealand botanists at their own institutions; but Kew has always maintained the happiest relations with them and a great interest in their work, and they continually add new specimens to the extensive representation. Samples of the collections recently made in the Montebello Islands were exhibited.

Apart from early researches on the floras of temperate North America and Central America, relatively less work has been done at Kew on American botany than on the plants of other continents. Exceptions to this generalization are the continued investigations concerning the botany of Trinidad and Tobago and British Guiana.

Mention must be made of Kew's contribution to the general classification of flowering plants as exemplified in the "Genera Plantarum", the "Index Kewensis", the new arrangement in "Families of Flowering Plants", and the contribution of members of the staff to the modern International Rules of Plant Nomenclature. Exhibits connected with these were varied and instructive.

The Kew collection of drawings, paintings, and photographs of plants is the most comprehensive in the world. Fine series illustrative of the work of both Kew artists and of that of others from the fifteenth century to the present day formed a notable feature of the exhibition. Other special exhibits illustrated researches (including cytological) in connexion with the National Dianthus Collection, the methods of preserving plant materials, the organization of herbarium work, the use and preparation of Floras, plant teratology, researches on the genus *Utricularia* and on *Bromus carinatus*, the use of genetics in taxonomy, and the introduction of plants to horticulture.

The researches carried out by the Herbarium staff at Kew are mainly taxonomic in the widest sense of this term. Modern taxonomy includes more than describing and naming dried specimens. The close co-operation of the Herbarium staff with that of other departments of the Royal Botanic Gardens, Kew, was evident in the numerous well-chosen examples of living plants from all parts of the earth and all connected with researches carried out by past or present scientists at Kew. Again, the importance to taxonomists of anatomical and physiological characters was emphasized by a large exhibit of apparatus, slides, and accounts of experiments staged from and illustrative of the work of the Jodrell Laboratory. Though the work at Kew is primarily scientific research, problems of immediate economic importance are often closely linked with and sometimes lead to special investigations. Samples of such connected with timber, fibre-, perfume- and oil-producing plants, species yielding drugs, and crops of various kinds were on view with the published results.

In the Library, visitors were able to see many of the valuable books from the libraries of Bromfield, Bentham, and W. J. Hooker, as well as others more recently acquired. Old herbals, manuscripts, diaries, and original drawings were also on view. Books purchased by the Bentham–Moxon trustees add greatly to the usefulness of the Library. A special exhibit showed some of the books written by members of the Kew staff and of the periodicals prepared at and, in part, published by Kew: the *Kew Bulletin*, *Icones Plantarum*, "Index Kewensis", and (edited at Kew for the Royal Horticultural Society) the *Botanical Magazine* and the "Index Londinensis".

SIZE AND SHAPE OF MACROMOLECULES*

By Prof. H. W. Melville, F.R.S.
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Polymer molecules of natural or synthetic origin can be generally classified as linear, branched or cross-linked. Sometimes these molecules are referred to as one-, two- or three-dimensional, respectively, the reason being that a linear molecule may be varied in length over a very considerable range, from a matter of a few angstroms up to as much as nearly a hundred thousand. Similarly, a two-dimensional molecule if placed on a plane surface may be extended in two directions up to the same kinds of limit. Correspondingly, a three-dimensional molecule may extend, without limit, in three dimensions. In this last-named case it is true to say that any isolated piece of polymer may represent one giant molecule, though in many actual cases there may be embedded in the three-dimensional array of atoms linear and branched-chain molecules, produced as a result of the synthetic process.

Progress in determining the size, shape and structure of these types has been very uneven, and

* Substance of a Friday Evening Discourse given at the Royal Institution on March 20.

this account is confined to a discussion of the problems that arise in dealing with molecules of synthetic origin only. Generally speaking, there are innumerable ways of building up linear molecules, the linearity of structure being assured by the chemistry of the synthetic process. It is equally easy to build up three-dimensional structures either by cross-linking linear molecules by suitable chemical methods, as in the vulcanization of rubber, or by choosing starting materials that would ensure the formation of three-dimensional molecules right from the beginning. The progress of synthesizing and characterizing the intermediate type of two-dimensional molecules proves to be very much more difficult, and little information is yet available about such substances. One-dimensional molecules are soluble in solvents, and hence it is possible to determine size, shape and often detailed structure comparatively easily. Three-dimensional molecules do not dissolve; at the most they only swell in suitable solvents, and hence the methods available for their study are very limited.

Linear molecules range in molecular weight from a few hundreds up to about ten million. In the low range, molecular weight can be measured by the classical methods of lowering of vapour pressure, though specially sensitive instruments are needed to measure the very small lowering of vapour pressure if, for example, the molecular weight rises to values of above twenty thousand. Small elevations of the boiling point can be measured by multiple-junction thermocouples to 10^{-4} deg. C., and even vapour-pressure thermometers under very closely controlled conditions can achieve a similar accuracy, so that molecular weights up to thirty thousand may be measured with an accuracy of about 5 per cent.

Beyond this the osmotic method is easily applicable. The problem here to be solved is that of obtaining suitable semi-permeable diaphragms. Cellulose prepared in a variety of ways in order to obtain a sufficiently porous structure is the most satisfactory method; but the procedures used for its preparation are empirical, and thus there is no means of controlling the production of such membranes except by trying in an actual osmometer. While considerable control of porosity can be achieved, the determination of molecular weights less than about twenty thousand is a very difficult and protracted matter. Recently, polyvinyl alcohol has been used with great advantage; its porosity to polymer can be made so low that molecular weights even down to a thousand may be measured. At the upper end of the scale of molecular weights, the problems are rather different. The osmotic pressure may only amount to a few millimetres of benzene when the polymer has a molecular weight of a million in a solution of less than 1 per cent by weight. The deviation of such solutions from ideal behaviour is so great that it is essential to extrapolate results to very low dilutions in order that molecular weights can be calculated. Since good cathetometers can read to about 10^{-2} mm., it is therefore practically impossible to measure molecular weights exceeding one million. In order to measure osmotic pressures of, say, 10^{-1} mm. a new kind of principle is used in which the weight of solvent that enters an osmotic cell is weighed directly in an instrument called an osmotic balance. By suitable arrangement of the geometry of the system and by using photoelectric means of detecting the movement of the beam of the balance, molecular weights of ten millions can be measured in a rather slow way because the ten million limit comes within the limits of practicability at the expense of slowness of operation.

Fortunately, there are other methods which operate satisfactorily in the higher ranges of molecular weights. The most direct method involves counting by the electron microscope the number of molecules in a given weight of polymer. With a resolving power of 50 A. it should be possible to 'see' molecules with a weight of a hundred thousand and more. The difficulties in doing such a direct experiment are quite formidable. To deposit on the sub-stage from a very dilute solution as little as, say, 10^{-16} gm. of material in the form of individual molecules free from dust is a problem easily stated but much less easily done. There is therefore much to be done along these lines before the method can become accurate. Similarly, the ultracentrifuge, while so useful with monodisperse biological macromolecules, is much more difficult to use with synthetic polydisperse material, especially when such polymers assume an elongated shape in solution.

Two less direct but more useful methods have more recently been developed. The first makes use of the optical turbidity exhibited by polymer solutions, which is the greater the larger the size of the dissolved molecule for a given weight concentration. The development of the photomultiplier photoelectric cell has made it possible to measure accurately such small turbidities; but since the turbidity of pure liquids is quite comparable with that of the solutions themselves, the method is not very suitable when the molecular weight falls below fifty thousand. At the upper end of the scale, that is, about a million, when the length of the molecules in solution is comparable to the wave-length of light, the marked dissymmetry of the scattered radiation makes it essential to measure the intensity of forward scattering as near the incident beam as possible. This makes for considerable experimental difficulties, though molecular weights up to about one million are readily measurable. Since scattering is proportional both to the number and weight of the polymer molecules, the molecular weights so obtained are a so-called weight average as contrasted with a number average found by osmometry. The ratio of weight to number average gives an indication of the polydispersity of a sample, the weight average always being the greater. If a sample were monodisperse, the ratio of weight to number average should be unity. However, the lowest published values amount to about 1·3 even with the most carefully fractionated material, and therefore it may be confidently stated that real fractionation of polydisperse synthetic polymers has not yet been achieved in spite of many statements which might lead one to suppose that such fractionation had been satisfactorily done. The other method, now being explored, makes use of the accurate estimation of end-groups in which one or more of the atoms is made radioactive. Some knowledge of the mechanism of synthesis is required—for example, whether there are one or two terminal groups of the required type in each molecule. By using initiator molecules of quite moderate radioactivity, such as azo compounds, molecular weights up to a million may be determined with very considerable accuracy and using as little as 10 mgm. of polymer.

Thus methods exist to cover the range of molecular weights required, and the only remaining difficulty is that some linear polymers—for example, poly-

ethylene, polyvinylidene chloride—only dissolve in solvents at elevated temperatures such as 100° C., and some polymers, such as polytetrafluorethylene, not at all. The upper limit in the range is not likely to be extended, for there seems to be a practical limit to molecular weights up to about ten million. This applies only to polyvinyl polymers. The main reason for this among those vinyl polymers which grow by radical mechanism is due to the phenomenon of transfer. A polymer radical during its growth may react with its environment, abstracting from it an atom and thus terminating the growth of that particular radical. Such a reaction, even at low temperatures, will therefore put a very definite limit on molecular weight. If synthesis could be conducted at very much lower temperatures, some increase in molecular weight might be possible. Even if this could be done, solutions of such high molecular weight are very easily broken down by relatively low rates of shear if subjected to movement, and thus the handling of such polymer solutions is subject to very considerable difficulty.

The process of transfer referred to above has another important consequence. When polymer accumulates in the system, there is a possibility that a polymer radical will attack a polymer molecule. The result is that the polymer molecule is converted into a radical, and this radical grows in an environment of the monomer, producing a branched-chain molecule. The reaction is specially likely to occur if the polymer radical is reactive, and therefore branched-chain molecules are likely to appear towards the end of the polymerization process. While such a process has been suspected for a long time, definite proof has only recently been obtained. Measurement of the dissymmetry of scattering in the light-scattering method gives information about the average distance between the end of molecules. According to theory, the square of the distance d is proportional to molecular weight M (or, in other words, M/d^2 is a constant), and this relationship holds quite accurately for some molecules such as polystyrene. With other polymers such as polyvinyl acetate, M/d^2 is not constant; that is, for a given molecular weight d is subject to considerable variation. This can only be due to the formation of branched-chain molecules, and the higher the value of M/d^2 the greater the degree of branching. A further confirmation of this point of view comes from the observations that, if polymers of a given molecular weight are synthesized at a series of increasing temperatures, d gets smaller and smaller; that is, branching becomes more pronounced.

Unfortunately, light-scattering theory is not yet in a position to interpret these results quantitatively, and hence a method of synthesizing branched-chain molecules of known structure is necessary. This can be done in the following way. A truly linear polymer is made at a low temperature. It is then dissolved in the monomer from which it was originally derived except that one of the carbon atoms is made radioactive. Polymerization is then carried out at a much higher temperature, when transfer to polymer occurs, with the result that radioactive branches are grafted on to the linear polymer. Thus the radioactivity so acquired is then a quantitative measure of the amount of branching that occurs.

The study of three-dimensional molecules is in a much less advanced stage. The only problem that so far has been quantitatively solved in some cases is the determination of the length of the polymer chain between cross-links. This is done by measuring the extent to which the polymer swells in a given liquid. Using knowledge derived from a study of the interaction of linear polymers and the same solvent, it is possible to compute the amount of branching which has taken place.

PRESSURE OF RADIATION*

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MECHANICS is the firmest branch of classical physics; and sooner or later each of the other branches was linked with mechanics by an experiment which usually proved vital to the new branch. In electrostatics, for example, Priestley's discovery in 1766 of the inverse square law governing the mechanical force between two electric charges made electrostatics into an exact science; there were similar events in magnetism (Michell, 1750) and in current electricity (Oersted, Biot and Savart, Ampère, 1820), and in heat the linking experiments were those of Joule (1840–50). One reason for the importance of all these great experiments is obvious: as soon as any connexion was established between mechanics and some new branch of physics, the magnificent system developed by Newton could be readily applied to the new branch.

The history of the study of light, however, was different. For, although Kepler[1] suggested in 1619 that light might exert a mechanical pressure, the experimental difficulties in the path of direct confirmation were insuperable for nearly three centuries. Without any such aid as a telescope or camera, Kepler had observed that the tail of a comet always streams out from the head in a direction which is primarily not along the comet's previous track like the trail of a celestial paper-chase, but which points almost exactly away from the sun. This can be seen from Fig. 1, where the telescope has been turned to follow the comet, thus drawing out the images of the fixed stars into streaks in the direction of the comet's motion. The tail is nearly perpendicular to this motion, as though blown sideways by a strong wind emanating from the sun. Kepler suggested that this wind might be due to light. While we are not sure that this 'light-wind' would be strong enough to cause the effect observed (material particles might contribute more to the wind than light does), Kepler's discerning observation and stimulating conjecture are the origin of the study of light-pressure.

Kepler's work was known to Newton, who accepted the observations; but Newton[2] pointed out that a comet's tail might equally well be likened to vapour rising from a body heated by the sun. However, the idea of light-corpuscles carrying momentum with them in a 'light-wind' was so appealing that a direct experiment was bound to be made. The first recorded attempt was that of Homberg[3] (1708), who believed that he had discovered the effect; but de Mairan and du Fay[4], who carried out a more serious experiment about 1750, failed to confirm Homberg's finding.

Michell, the inventor of the torsion balance, also attempted to detect the pressure of light in about 1750; his work was described by Priestley[5]. Michell did not actually use the torsion balance, although in the hands of later experimenters this proved to be a

* Substance of a Friday Evening Discourse given at the Royal Institution on March 6.

Fig. 1. Comet Morehouse (1908 III), September 29, 1908. Taken with the 30-in. reflector at Greenwich. Reproduced by permission of H.M. Astronomer Royal

vital device in observing the effect. Michell himself used a suspension resembling a compass needle with a thin vane mounted at one end. On to this vane he focused the rays of the sun and found that the vane moved. What he observed, almost certainly, was an effect due to convection currents in the air surrounding the heated vane; such currents have frequently been a serious cause of disturbance in delicate experiments.

The most obvious way of reducing convection currents was to place the vane in an evacuated chamber. This step was taken by Bennet[6] (1792), who found that he could then detect no repulsion distinguishable from the effects of direct heating. From his careful experiment with its negative result, he speculated against the corpuscular theory; and he was followed by Thomas Young[7] who, in his celebrated Bakerian Lecture of 1802, quoted with approval Bennet's conclusion that the absence of light pressure was evidence in favour of light being a wave and not a corpuscular motion.

Young's statement was slightly curious, since Euler[8] (1742) had already conjectured that waves would exert a force against an opposing surface. It is therefore worth looking at both the corpuscular and the wave model. A moving corpuscle will obviously give an impulse to an opposing surface, and a stream of corpuscles, such as the bullets from a machine gun, will exert the equivalent of a steady force. It is not so obvious that a succession of waves will do the same thing, although we have only too much practical experience of the mechanical effects of single shock waves in blowing down buildings. A succession of small shock waves, such as can be generated by a repeated electric spark, can be focused by a mirror to produce impulses strong enough to turn a small paddle wheel.

A succession of longitudinal sinusoidal waves (continuous sound waves of about 3,000 c./s. are suitable) can be shown experimentally to repel a suspended vane (Pohl's sound radiometer). At first sight it is not easy to see why such a wave should produce this effect, because it can be conceived as producing a series of alternate pushes and pulls as the compressions and rarefactions strike the surface, and in free space the compressions and rarefactions are usually regarded as equal in magnitude. Near a surface, however, in order to preserve equality of motion in the forwards and backwards displacement of individual particles, the pressure rise on compression exceeds the fall on rarefaction. There is, therefore, a small net push on the surface.

Finally, the simplest model of transverse wave can be shown to exert a force by the device of Fig. 2. Transverse waves generated at H on a string and travelling towards the fixed end S are damped out by a pair of pulleys P and P'. In any general position of the string such as that illustrated, there is a resultant force R on one of the pulleys due to the two tension forces T acting on it, and R is always a component acting away from H. The pulleys thus tend to move away from H under 'radiation pressure', and the effect can be demonstrated if the pulleys are mounted on a lightly constructed boat floating in a trough of water.

From all these examples it appears that waves are just as capable of exerting a force as corpuscles are. The argument of Bennet and of Young was therefore incorrect; the reason why the pressure of light was still undiscovered was mainly that it was too small to be isolated from the various disturbing effects.

In 1873 it almost looked as though Crookes[9] had detected the pressure of light, when he made a blackened surface in an apparent vacuum move under the influence of light. This, however, turned out to be the 'radiometer effect' which is due, very roughly, to the molecules still left in the 'vacuum' hitting the heated surface and coming off at greater speed. Any doubt about the origin of the radiometer effect was quickly removed by an elegant experiment of Schuster[10] which showed that for any action on the vane there was an equal reaction on the gas.

1873 was also the year in which Maxwell's "Treatise on Electricity and Magnetism" was published. Maxwell showed that it was possible for electromagnetic waves to travel through the ether, and that these waves would be made up of transverse alternating electric and magnetic field vectors mutually perpendicular to one another. Maxwell[11] also showed that there was a pressure in the medium carrying the waves, and that this pressure was exerted normally to the wave fronts, and he assumed that this pressure would be transmitted to any surface on which the waves were incident. J. J. Thomson[12], in a footnote to the third edition of Maxwell's "Treatise", made the assumption more plausible by proposing a mechanism whereby the force would be communicated to a conducting surface. The alternating magnetic field of the wave would induce a current in the conductor, and the field of the induced current would react back on the inducing

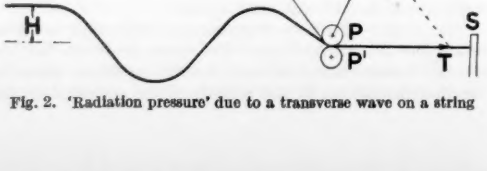


Fig. 2. 'Radiation pressure' due to a transverse wave on a string

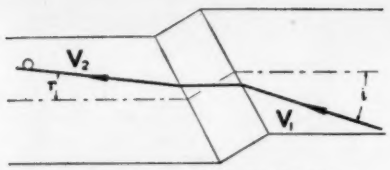


Fig. 3. Corpuscular model of refraction

field so as to cause a repulsion between the wave and the conductor. Maxwell's theory, with its impressively simple result, enabled him to calculate the repulsion due to light under any given conditions. Full sunlight falling on a black surface on the earth would, for example, exert a pressure of about 5×10^{-5} dyne/cm.^{2}, which is about the same pressure as would be generated gravitationally by a single layer of atoms spread over the same surface.

Maxwell's calculation showed the experimenters how minute a force they would have to observe (Osborne Reynolds[13] calculated that it was about a thousand times as small as the Crookes radiometer effect), and it took another twenty-six years before Lebedew[14] in Russia and Nichols and Hull[15] in the United States were able to show that pressure of the predicted amount was in fact exerted by light. The difficulties that they had to overcome were threefold: to make suspensions so delicate that they would turn appreciably under the small forces involved; to defeat convection troubles; and to eliminate the 'radiometer' effect. The last two troubles were overcome simply by improving the vacuum. With the successful outcome of these experiments, the link between light and mechanical force was finally established.

There is an interesting consequence of the pressure of light: light must carry momentum, as was first seen from the electromagnetic point of view by J. J. Thomson[16]. A body emitting light is therefore giving momentum to it, and hence there must be a reaction on the emitting body. This reaction was detected by Poynting and Barlow[17], who described their experiment in the Bakerian Lecture for 1910.

Although under terrestrial conditions the pressure of light is very small, it is of great significance. The fact that light carries momentum enabled Einstein[18] to give a convincing illustration of the equivalence of mass and energy. Light pressure is thought to be a vital factor in the structure of stars, and to set an upper limit to their size. The radiation pressure outwards at the surface of a star tends to increase with stellar size at a greater rate than does the gravitational pull inwards at the surface. Above a critical diameter, therefore, an atom on the surface tends to be blown away by radiation rather than retained by gravity.

An interesting effect of a refracting surface on the momentum of radiation can be predicted and observed; this is easily seen from a model which demonstrates the corpuscular theory of refraction. The model (Fig. 3) consists of two level planes at different heights, separated by an incline; the lower plane corresponds to the optically denser medium, and the incline to the optical interface. If a ball is rolled over the upper plane towards the lower one with constant speed, V_1, it gains speed down the incline by an amount which is independent of the angle of approach, i. It therefore emerges across the lower plane with constant speed V_2 at an angle r to the normal, and it is easy to see that

$$\sin i/\sin r = V_2/V_1 = \text{a constant}.$$

The model thus obeys Snell's law, and it can also be made to show the phenomena of critical angle and total internal reflexion. It is, in fact, the simplest example of the type of model used in the investigation of electric optics.

The model is, of course, imperfect, as can be seen from its implication that light travels faster in a denser medium; but since no model can be perfect, this one—which has been shown to be in several respects satisfactory—should not be completely rejected without further trial. In particular, it predicts that the momentum of the corpuscles is greater in the denser medium by a ratio equal to the refractive index. A stream of corpuscles will therefore impinge with a greater momentum on a surface immersed in the denser medium than the same stream would have done in the rarer medium. A corresponding prediction is made by the wave theory, since the radiation pressure is equal to the energy per unit volume, and this obviously increases as the waves slow down in the denser medium. Finally, since the momentum of an individual photon is h/λ, where h is Planck's constant and λ the wave-length, this momentum is greater in the denser medium since λ is now smaller in the ratio of the refractive index.

All theories, therefore, make the same prediction: when light passes into a denser medium it gains momentum so that the ratio of the final momentum to the initial momentum is equal to the refractive index. Since momentum is conserved, there must be

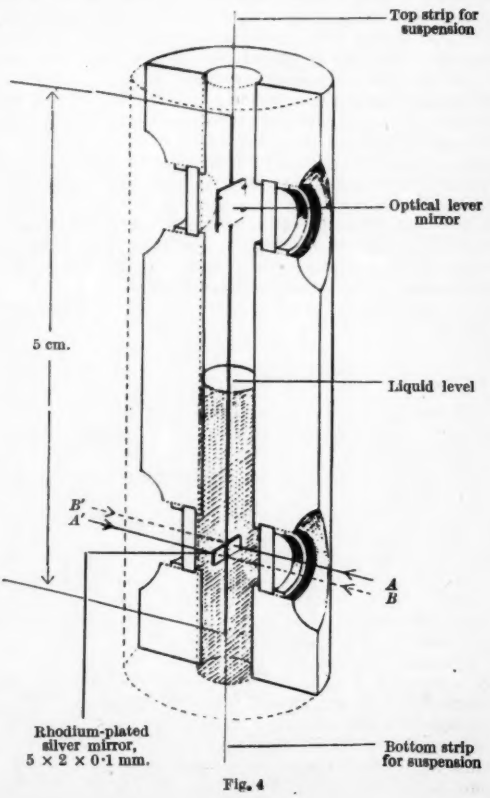


Fig. 4

a reaction on the surface separating the two media, directed from the denser to the rarer medium. This can easily be seen from the corpuscular model. The reaction was observed experimentally by Barlow[19] (1912).

Recently the increase in momentum of the light itself has been directly observed at Aberdeen, the preliminary form of the experiment being already summarily reported[20]. The experiment has involved comparing the forces exerted by a beam of light on a small vane suspended by a torsion balance, first in air and then with the same beam and the same vane immersed in various liquids. Previous determinations of radiation pressure have almost all been made *in vacuo* because of the difficulties due to convection currents in air, but the present experiment requires that the pressure should be measured in liquids, where convection troubles and other thermal effects are likely to be much more acute than in any gas. Fortunately, it is possible to distinguish the effect of radiation pressure from the other effects by the fact that it is instantaneous, whereas the others, being thermal, take a few seconds to develop fully, depending on such factors as the heat capacity of the vane. A quickly responding suspension is therefore required, and one with a response time of about half a second was used. Convection troubles were minimized by making the suspension small (the reacting vane was of rhodium-plated silver, $5 \times 2 \times 0{\cdot}1$ mm.) and mounting it in a narrow (8-mm. diameter) tube, as shown in Fig. 4. A stretched suspension was used, for it would have been impossible to operate a vane suspended from above only, because surface tension would have dragged it to the side of the containing tube. A second mirror was added at the top of the suspension to enable the orientation to be observed. A minor problem was the technique of assembly of the suspension, since this had to be immersed in several liquids, and could therefore contain no cement soluble in any one of them. To minimize effects due to thermal causes, the experimental arrangement was made as symmetrical as possible. Two light beams were first thrown on to the vane (suspended symmetrically with its face vertical and its longest edge horizontal) in positions AA' so as to generate an anti-clockwise couple on the vane; the light beams were then rapidly moved to positions BB', where they would generate an equal clockwise couple.

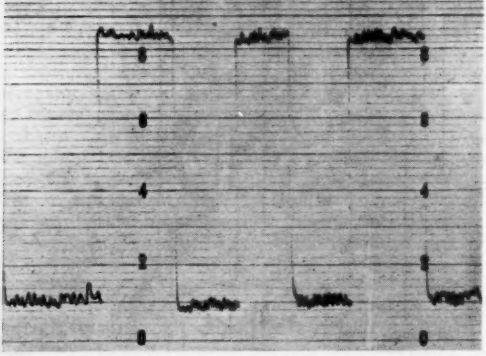


Fig. 5. Record of deflexion due to radiation pressure of light in air. Magnitude of deflexion, 5×10^{-5} radian. Disturbances probably Brownian

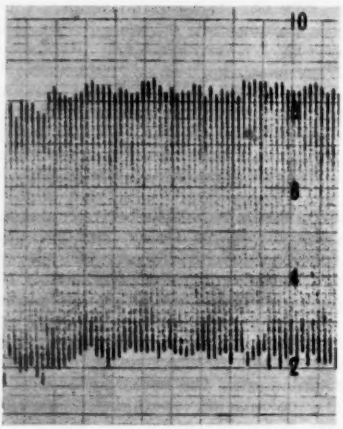


Fig. 6. Record of deflexion due to automatic switching of light in liquid (xylene)

Owing to the quick response required in the suspension, it was necessarily insensitive, and the typical change in orientation caused by moving the light beams was of the order of 5×10^{-5} radian, equivalent to the movement of a galvanometer spot of $0{\cdot}1$ mm. at a scale distance of 1 m. Incidentally, this is only about fifty times the root mean square of the Brownian fluctuations in the system. Both they and the change in orientation consequent upon moving the light beams can be seen in Fig. 5, which shows a record taken with air in the tube. To obtain satisfactory records of such small movements, it was necessary to use an optical lever amplifier; this had already been developed for other purposes[21], and it could, if necessary, be made so sensitive that with a mirror 5 mm. in diameter it would detect reliably a rotation so small that no part of the mirror moved by more than about 2×10^{-10} cm., or about one-hundredth of an atomic diameter.

The deflexions in liquids were not nearly so easy to interpret nor was the zero nearly so steady; but it was noticed that the first kick after moving the light beams was roughly of the correct magnitude, and it was thus possible to obtain preliminary observations of the increase in pressure in liquids. In order to isolate the immediate kick due to radiation pressure, it was decided to switch the light beams mechanically about once per second, so that an oscillating record (Fig. 6) was obtained. The air and liquid records could not then be compared directly, because of the increased damping of the oscillations of the vane in the liquid. This difficulty could be simply overcome by adding a very small magnet to the suspension, and arranging to deflect it by a magnetic field which reversed with the same frequency as that at which the light beam was switched. In principle it would have been possible to arrange the light and magnetic deflexion in anti-phase, so that the strength of current generating the magnetic field required to balance the light pressure could have been taken directly as a measurement of the latter pressure. Since the vane would then be at rest both in air and in liquid, no damping effects would have had to be allowed for. In practice, however, it was easier to find the alternating deflexion due to the light pressure, and then to find the current required to produce an equal alternating deflexion in the same

VARIATION OF RADIATION PRESSURE WITH REFRACTIVE INDEX

Liquid	Water	Ethyl alcohol	Carbon tetrachloride	Xylene	Benzene	Carbon disulphide	Standard error (per cent)
Observed reflexion ratio	1·274	1·305	1·413	1·424	1·432	1·539	± 1·5
Corrected pressure ratio	1·348	1·374	1·478	1·502	1·517	1·637	± 2
Mean refractive index	1·329	1·358	1·457	1·489	1·493	1·613	± 0·1
Discrepancy (per cent)	+1·4	+1·2	+1·4	+0·9	+1·6	+1·5	

medium. This method again eliminated the viscosity of the medium.

The foregoing experiment has been carried out by Mr. J. C. S. Richards (University of Aberdeen), aiming at an over-all accuracy of one per cent. For this accuracy, many observations (more than four hundred) were necessary on each liquid, to average out the effects of Brownian and other disturbances. It was also necessary to allow for effects such as the slight change of reflectivity of the vane on immersion in liquid, and the loss of light in the medium as it crosses the glass/air or glass/liquid interfaces on its way to the vane. Mr. Richards's results are shown in the table.

This table shows that the proportionate increase in momentum is within 1 to 1·5 per cent of the refractive index, the experimental results being consistently high by a small amount which is probably due to some unforeseen correction that we have not allowed for. The agreement is amply good enough, however, for us to conclude that the effect has been satisfactorily confirmed. Not only, therefore, does light press against a mirror but it also gains or loses momentum whenever it crosses a refracting boundary.

[1] Kepler, J., "Omnia Opera", **7**, 110, Ed. Ch. Frisch (Frankfurt, 1868).
[2] Newton, I., "Principia", Lib. 3, Prop. 41 (1687).
[3] Homberg, "Histoire de l'Academie", 21 (1708).
[4] de Mairan, M., "Traité Physique et Historique de l'Aurore Boreale", 2nd ed., 289, 367 (Paris, 1754).
[5] Priestley, J., "History of Vision, Light and Colour" (London, 1772).
[6] Bennet, A., *Phil. Trans.*, 81 (1792).
[7] Young, T., *Phil. Trans.*, 12 (1802).
[8] Euler, L., "Recherches Physiques sur la Cause des Queues des Cometes" (Berlin, 1746).
[9] Crookes, W., *Phil. Trans.*, **163**, 287 (1873).
[10] Schuster, A., *Phil. Trans.*, **166**, 715 (1876).
[11] Maxwell, J. C., "Treatise on Electricity and Magnetism" (Clarendon Press, 1873).
[12] Thomson, J. J., footnote to Maxwell's "Treatise", 441; 3rd ed. (Oxford, 1892).
[13] Reynolds, O., *Phil. Trans.*, **166**, 725 (1876); **170**, 727 (1879).
[14] Lebedew, P., *Ann. Phys.*, **42**, ser. 4, 433 (1901).
[15] Nichols, E. F., and Hull, G. F., *Phys. Rev.*, **13**, 307 (1901).
[16] Thomson, J. J., "Recent Researches in Electricity and Magnetism" (Clarendon Press, 1893).
[17] Poynting, J. H., and Barlow, G., *Proc. Roy. Soc.*, A, **83**, 534 (1910).
[18] Einstein, A., see, for example, "Atomic Physics" by Max Born, 52, 4th ed. (London: Blackie and Sons, Ltd.).
[19] Barlow, G., *Proc. Roy. Soc.*, A, **87**, 1 (1912).
[20] Jones, R. V., *Nature*, **167**, 439 (1951).
[21] Jones, R. V., *Proc. Phys. Soc.*, B, **64**, 469 (1951).

OBITUARY

Dr. G. F. Herbert Smith, C.B.E.

GEORGE FREDERICK HERBERT SMITH was born on May 26, 1872, eighty-one years ago. Well known to mineralogists for his early work on geometrical crystallography and on the scientific study of gemstones, he was better known to a wider circle for his work as honorary secretary of the Society for the Promotion of Nature Reserves and numerous other councils and committees having to do with the preservation of wild life and the protection of Nature. Most of this work, however, was done in the fifteen years since his retirement from the Natural History Museum, where he had served successively as assistant in the Department of Mineralogy, assistant secretary and secretary of the Museum and keeper of minerals for a total of forty years.

Herbert Smith came to the Department of Mineralogy at twenty-five by way of Winchester and New College, Oxford, with firsts in the finals honours schools in mathematics and physics. He spent part of a year at Munich studying under Paul Groth, and at the Museum he produced some important papers on geometrical crystallography and devised a three-circle goniometer which he used for working out the intricate problems of the crystallography of the gold telluride, calaverite (1902), and the sulpharsenite of lead, sartorite, from the famous Binnenthal locality. Early in his career at the Museum he became interested in the study of gemstones and scientific methods of identifying faceted stones. To this end he designed a convenient form of refractometer and put in the hands of jewellers an instrument that all could use effectively with very little difficulty. From 1912 he was one of the examiners for the diploma in gemmology initiated by the National Association of Goldsmiths and so remained after its Education Committee became the Gemmological Committee in 1924 and finally formed the Gemmological Association in 1931. He was president of the Association in succession to Sir William Bragg from 1942 until his death. Among gemmologists his name is a household word, and his book "Gemstones", now in its twelfth edition, contains the record of his accumulated knowledge and experience in the scientific study of gemstones both as minerals and as gems.

After the death of Charles E. Fagan in 1921, Herbert Smith left the Department of Mineralogy to become assistant secretary of the Museum. Thenceforward he became involved in administrative work. During the early part of his period in this office an important event was the move in 1924 of the zoological collections preserved in spirit into the completed eastern half of the New Spirit Building. It was probably thanks to Herbert Smith's efforts that the Empire Marketing Board made a generous grant to enable a third quarter of this building to be completed in 1930 to provide accommodation for the overcrowded Department of Entomology pending the erection of its own building (which was in the event not completed until 1952 although the south half was occupied in 1936). Some of the work of preparing evidence for the Royal Commission on Museums and Galleries in 1927 fell to Herbert Smith, and he also had the congenial task of arranging for the celebration of the fiftieth anniversary of the opening of the Natural History Museum (1931). Several collecting expeditions in East Africa were organized during this period, culminating in the successful 'Ruwenzori' Expedition by the late F. W. Edwards and Dr. George Taylor in 1934. Accounts of these expeditions were published in the *Natural History Magazine*, a museum publication which Herbert Smith edited throughout its short life during 1927–36. The preparation and sale of postcards illustrating speci-

mens in the collections was another of Herbert Smith's innovations and was completely successful.

He did many things to encourage a corporate spirit in the Museum staff, strongly supporting the formation of a sports club and rifle club, of which latter he was himself an active member. With three other senior members of the staff he organized the staff association for the scientific staff. This association was affiliated to the Society of Civil Servants, of which Herbert Smith was one of the honorary secretaries, 1918–25. He was also editor of its journal, 1923–30, and later a vice-president and president, 1929–32. It was typical of Herbert Smith that, in connexion with this work for the Society of Civil Servants, he arranged a special train to take its members and other Civil servants to Richmond, Yorkshire, to view the total eclipse of the sun in 1927. He wrote a guide to the eclipse and provided "pieces (5 by 2 ins.) of dark glass for viewing the Sun". It was no fault of his that cloud obscured the view.

The Civil Service Arts Council he served for fifteen years as honorary secretary and treasurer, and he also served on the Civil Service Sports Council and was chairman of its publicity committee from 1946. As another spare-time activity he represented the Trustees of the British Museum on the Council of the Royal Albert Hall from 1930 until his death, and was chairman of the Executive Committee, 1941–47, and a member of the Finance Committee, 1941–51.

In the last two years of his service in the Museum, he returned to the Department of Mineralogy as keeper and did some good work in arranging new exhibits of gemstones and semi-precious stones in specially illuminated cases. These unfortunately had to be dismantled only two years later on the outbreak of war so that the specimens could be put in a safer place.

Herbert Smith's work for the Society for the Promotion of Nature Reserves began in 1921 when, succeeding Charles E. Fagan in the Museum Office, he took over also the secretarial work of the Society. During his long term of office, the activities of the Society greatly increased. It was this Society that took the initiative in 1941 of getting together a conference to consider Nature protection in post-war reconstruction. This conference in its turn appointed, at the suggestion of the responsible Minister, the Nature Reserves Investigation Committee in 1942. Of both these bodies Herbert Smith was honorary secretary, and he was also chairman of the Geological Reserves Sub-Committee. These committees co-ordinated the work of no less than twenty-four regional committees in England and Wales. Two reports were issued in 1945, shortly after the end of the War, and their detailed recommendations were almost all incorporated in the report of the Wild Life Conservation Special Committee presented to Parliament in 1947 [1,2]. The establishment of the office of Nature Conservancy was a direct outcome of the recommendations of this Committee.

Herbert Smith had been chairman of the Wild Plant Conservation Board since 1931 and was interested, too, in the Society for the Preservation of the Fauna of the Empire and the Convention for the Protection of the Fauna and Flora of Africa. In a wider field he was one of the British delegation to the International Conference for the Protection of Nature held at Brunnen in 1947 [3] and of the later conference of Government representatives held at Fontainebleau under the auspices of Unesco in Paris during the following year. There he was chairman of the committee charged with the drafting of the constitution. His committee completed its task in two days and the finished draft was ready for the closing session. He attended the first General Assembly in Brussels in 1950 as head of the British delegation, and since that year he held the office of a vice-president of the Union.

Herbert Smith had outlived most of the friends who had known him as a young man. To many who served on his committees he may have seemed reserved, autocratic and obstinate. He was, in fact, determined to get things done and he usually succeeded. He understood what things were practicable, and by hard work and persistence he accomplished much. That was his reward for the devotion with which he worked for the protection of Nature, to which cause he gave, voluntarily and unpaid, almost all his time for the fifteen years that followed his retirement from the Natural History Museum.

He died after a short illness on April 20, 1953, and leaves a married daughter. His wife, a daughter of the late John Ellerton, of Leamington, died in 1936. He was a Fellow of the Royal Astronomical Society, a member and a past vice-president of the Mineralogical Society, and for many years a Fellow of the Geological Society and a member of the British Association. He was awarded the C.B.E. in 1949.

W. Campbell Smith

[1] *Nature*, **160**, 457 (1947).
[2] *Nature*, **160**, 809 (1947).
[3] *Nature*, **160**, 320 (1947).

NEWS and VIEWS

Geography at Glasgow: Prof. A. Stevens

The retiring professor of geography in the University of Glasgow, Prof. A. Stevens, commenced his long association with the University as an arts student and graduated M.A. in 1907. After a short break, he continued his stud in the Faculty of Science and obtained his B.Sc. as a geologist. In 1914 he joined Shackleton's South Polar expedition, and was marooned for two years in the Antarctic. On returning home Stevens served with the Army until the end of hostilities. In 1919 he was invited to organize a Department of Geography at Glasgow; a lectureship had been established in 1909 but was in abeyance. It was not until as late as 1947 that a chair of geography was established with Stevens as the first professor. He has devoted his energies very largely to the development of the Department on what he believed to be a sound basis; the emphasis has been on regional geography. At the same time, he has contributed notably by papers and in discussion to theoretical aspects of his subject; his presidential address to Section E (Geography) at the British Association in 1939 is an example. Prof. Stevens has not been a prolific writer; but his papers have covered a wide field and each has been a stimulus to his fellow workers. There have been contributions of lasting value on physical geography in which his earlier interests undoubtedly lay, and latterly papers to the Institute of British Geographers have dealt with problems of population distribution in the British

Isles. He has also been directing research on a hypsometric survey of Scotland, and it is hoped that his retirement will not cut short this work.

Dr. Ronald Miller

RONALD MILLER, who is to succeed Prof. Stevens at Glasgow, was the first member of the University of Edinburgh to graduate as M.A. with honours in geography, in 1931. As an Orcadian naturally interested in the sea, he then turned appropriately to oceanography and, after two years as a Carnegie Research Scholar, working in the Marine Laboratory of the Fishery Board in Aberdeen and on its research vessel, he earned the degree of Ph.D.(Edin.) for his contribution to the hydrography of the northern North Sea. As an assistant lecturer in geography under Prof. H. J. Fleure at Manchester (1933–36), he developed an interest in cartography, a subject on which he has since published several papers. He then entered the Colonial Service as geography specialist at Katsina Higher College, Nigeria, which was intended eventually to attain university college status. Working with African students in the field, he published studies of the Hausa and was engaged in further research on Nigeria when the Second World War supervened and he was embodied from the Supplementary Reserve into the Nigeria Regiment, where he served until 1944 and then reverted to civil employment at the request of the Colonial Office. He visited many parts of West Africa and acquired an intimate knowledge of the Hausa people and fluency in their language. He returned in 1946 to his Alma Mater as lecturer under Prof. A. G. Ogilvie, and has been primarily concerned with physical aspects of geography and with departmental work in the field. He has written on African topics and is continuing his work on Nigeria.

Harrison Howe Lecture: Prof. H. C. Brown

THE Harrison Howe Lecture for 1953 of the Rochester Section of the American Chemical Society will be delivered on November 21 by Prof. Herbert C. Brown, professor of chemistry in Purdue University, Lafayette. The Lecture was founded in 1945 to commemorate the services to chemistry of Harrison E. Howe and his influence on American industry through his researches. Prof. Brown has been chosen this year for his contributions to stereochemistry and also for his work in the synthesis of hitherto unknown boron hydride derivatives. In the field of stereochemistry his studies have shed new light on the abnormal behaviour of strained molecules, and recently he has developed a method of measuring the magnitude of the strain factor in structurally related compounds. His work on the chemistry of boron hydride was conducted at the University of Chicago during the Second World War as part of a war-time project connected with atomic energy research and is noteworthy for the preparation of a new type of organoboron substance which is very useful as a reducing agent and source of hydrogen.

Advisory Council on Scientific Research and Technical Development

THE Ministry of Supply announces the following appointments to the Minister's Advisory Council on Scientific Research and Technical Development: Prof. H. W. Melville, Mason professor of chemistry in the University of Birmingham; Prof. J. L. M. Morrison, professor of mechanical engineering in the University of Bristol; Prof. L. Rosenhead, professor of applied mathematics in the University of Liverpool; Prof. I. N. Sneddon, professor of mathematics in the University College of North Staffordshire; Prof. A. R. Todd, professor of organic chemistry in the University of Cambridge.

Committee on Adult Education

MISS HORSBRUGH, Minister of Education, has appointed the following committee to inquire into the adult educational service of Great Britain: Dr. Eric Ashby, vice-chancellor, Queen's University, Belfast (chairman); Mr. A. L. C. Bullock, censor of St. Catherine's Society, Oxford; Prof. W. L. Burn, professor of modern history, University of Durham; Mr. T. Mervyn Jones, chairman, Wales Gas Board; Sir Wilfrid Martineau, formerly chairman of the Birmingham Education Committee; Mr. C. M. Skinner, a member of the Court of Governors, University of Manchester; and Mr. G. B. Thorneycroft, member of the General Council of the Trades Union Congress. The committee's terms of reference are: "To review the present system by which the extra-mural departments of universities, the Workers' Educational Association and the other responsible bodies provide local facilities for adult education, with special reference to the conditions under which these facilities are organized and are aided by grants from public funds; and to make recommendations".

Technological Education in Britain

THE reply of Mr. Kenneth Pickthorn, Parliamentary Secretary to the Ministry of Education, to an adjournment debate on technological education, initiated by Mr. James Johnson on May 21, did not indicate that the Government has yet formulated any real policy. Mr. Pickthorn rightly pointed out that there had not yet been much time for technical colleges to obtain grants, or promises of grants, under Circular 255, but he could only express the hope that colleges with courses which attract the maximum—the advanced rate of grant of 75 per cent—would develop more and more into institutions for technological work only, and that the remaining colleges would concentrate on the needs of technicians. Mr. Johnson had particularly stressed, besides the desirability of developing the work of the major technical colleges (some thirty of about two hundred), the shortage of science teachers in secondary schools, pointing out that in 1951 not one of the 51 honours graduates in the honours school of chemistry at the University of Oxford went into teaching. Mr. Pickthorn said he thought that the quantitative shortage of science teachers is being exaggerated; indeed, the situation is slightly improving. He emphasized the impossibility of finding a rapid solution of this problem.

City and Guilds of London Institute: Report for 1951

THE annual report of the council of the City and Guilds of London Institute for 1951 (pp. 64; 1952), in referring to the election of the Duke of Edinburgh as president, recalls that in 1881 the Prince of Wales became the first president and that the office has remained vacant since he became visitor and patron on accession to the throne in 1901. The report records a year of consolidation, but no long-term solution of the acute problem of accommodation is possible until the resources of the Institute are considerably increased. The council is desirous that the Institute's work in the field of art should be more widely known and appreciated. Honorary associate-

ships were conferred on nine professors of not less than five years standing at the College, and the fellowship was conferred on Atholl Blair and H. Shoosmith. A Finsbury Medal has been instituted at the instance of the Finsbury Technical College Old Students' Association, and this body, in terminating the Streatfeild Memorial Lectures, has also offered the balance of the Fund to establish a major annual prize in a suitable branch of chemical technology, if possible where emphasis can be placed upon practical work. The first new Insignia awards (see *Nature*, **170**, 828; 1952) were expected to be made during the winter of 1952, and the Institute believes that the introduction of the award will encourage students to take full advantage of the facilities provided in industry and technical colleges and lead to recognition of the value of practical training and experience. A deficit of £6,278 on the year and depreciation of the Institute's investments threaten curtailment of activities unless new income can be found.

Jubilee of the School Nature Study Union

The latest issue of the School Nature Study Union journal (*School Nature Study*) represents a memorable event in the life of the organization—its fiftieth birthday. The Union was founded in 1903, largely owing to the enthusiasm of the Rev. Claude Hinscliff and Miss Kate Hall, and soon became the means of promoting considerable interest in the study of natural history in schools. The first president was Sir George Kekewich, and the vice-presidents included Lord Beauchamp, Sir John Cockburn, Sir Lauder Brunton, Mrs. Humphrey Ward and, later, Mr. H. G. Wells. During its life, many eminent biologists have served the Union as presidents or in other capacities, although probably no names are more pre-eminent than those of Miss C. Von Wyss and Mr. H. E. Turner, who were both members of the original committee formed in 1905 until their resignation in 1936. Besides the journal, which has been appearing for forty-eight years, the School Nature Study Union has performed a most useful service to teachers and others in the production of an extensive series of leaflets which give practical advice on how to teach natural history more effectively. Cordial greetings are extended to the School Nature Study Union in its jubilee year.

Botanical Gallery at Bolton

Though the Museum and Art Gallery at Bolton was built just before the War it was only possible recently to install a botanical gallery. This is described in the *Museums Journal* for May by Mr. A. Hazelwood and indicates clearly some of the aspects of botany which can be so illustrated. Naturally recourse to modelling was considered essential, and the first exhibit is an enlarged model of a poppy which is used for demonstrating terms applied to the various parts of a flowering plant. Other exhibits deal with the morphology and some aspects of the physiology of the flowering plant, root forms, shoot forms, nutrition and adaptation to specialized environments, together with the fruit, dispersal and germination of a variety of plants. Another section is systematic and, after a series of colour transparencies of microscopic forms, follows with models of the larger thallophytes to the Angiosperms. Emphasis is given to the illustration of forest trees, and the series concludes with exhibits showing plants as food.

Herbarium of Indian Plants

The discovery of an important herbarium in a recent acquisition by the Liverpool Public Museums is related by Mr. H. Stansfield, keeper of the Department of Botany, in the March number of the *Museums Journal*. This collection, which was given by the Liverpool Chemists' Association, consisted of several thousand specimens with no data, and by patient investigation Mr. Stansfield has been able to record its history. By noting various clues and following several lines of investigation, he was able to prove that the plants were those on which the text and illustrations of J. F. Royle's "Illustrations of the Botany of the Himalayan Mountains and the Flora of Cashmere" were founded. Some of the plants were collected in the plains of India of the north-west provinces, some are from the mountainous tract between the Sutlej and the Ganges and others from the valleys of Kashmir (Cashmere). The plants from the last-named locality were obtained during 1828–31 by native collectors. The herbarium with its important type-specimens has been placed in good order and will no doubt be consulted by many workers.

Feeding Mechanisms in Deep-Sea Fish

Much of our knowledge of the habits and functioning of deep-sea fishes must, perforce, be derived from indirect evidence. From dissections of preserved material, the late Dr. V. V. Tchernavin has carefully reconstructed the probable sequence of movements involved in feeding in a bathypelagic stomiatoid teleost *Chauliodus*. His conclusions have now been published by the British Museum (Natural History) in a volume entitled "The Feeding Mechanisms of a Deep-Sea Fish *Chauliodus sloani* Schneider" (pp. viii+101+10 plates; 1953; 30*s*.). Jaw and head movements, basically similar to those of other teleosts, but on a much exaggerated scale, enable *Chauliodus* to capture and ingest prey larger than itself. For comparison with *Chauliodus*, the feeding mechanisms of certain other vertebrates are described briefly. Other valuable details described in the volume are the operation of breathing valves, the distribution and possible significance of light organs in *Chauliodus*, and the dissimilar feeding mechanism of another bathypelagic teleost, *Saccopharynx* (order Lyomeri). There is an extensive bibliography.

Linen Research Association: Report for 1952

The report of the council of the Linen Research Association for the year ended September 30, 1952 (pp. 24; from the Association, Lambeg, Northern Ireland; 1952), records steady progress in almost every section of the Association's activities. Research on flax production has again been a matter of concern to the industry, and the council records its thanks to the Flax Development Committee for continued support of its research on flax scutch. The flax-production scheme in England is now to continue on a permanent basis, and also research work in Norfolk, but on a reduced scale. In the work on rayon staple, various causes of shading faults in plain dyed fabrics have been revealed and recommendations made for reducing the faults to a minimum. Arrangements have been made for the manufacture of the Linra photo-electric yarn irregularity gauge to assist in keeping yarn irregularity below a fixed level, and comparative tests of the Linra modified roller-breaker

against other breakers are being arranged. Surveys in factories have been specially directed to the investigation of yarn-winding processes and of humidification. In sizing, promising results have been obtained in trials of a new brushing unit on a slashing machine, and fundamental work on the relationship between yarn and cloth has continued. Methods of bleaching linen goods have been evolved which indicate that still higher quality can be achieved.

Fluorosis and Pollution

REPLYING to an adjournment debate in the House of Commons on May 14, initiated by Dr. Barnett Stross, of Stoke-on-Trent, who pressed for the instigation of a local inquiry into the incidence of fluorosis due to atmospheric pollution, the Parliamentary Secretary to the Ministry of Health, Miss Patricia Hornsby-Smith, said that, on the evidence available, neither the Ministry nor the Medical Research Council believes that an inquiry in that area is essential. The wider problem of fluorine would, however, have to be one of the items covered in the investigations now being undertaken by the Minister of Housing and Local Government into air pollution, as particularly applied to industrial areas. With regard to the question of fluorine in water supplies, Miss Hornsby-Smith said she did not wish to make any comment pending a full study of the report of the British mission to North America inquiring into this question.

X-Rays accompanying μ-Meson Capture

INTERESTING observations on the X-rays accompanying μ-meson capture by nuclei are reported through the rather unusual channel of a 'press release' from Columbia University. Negative μ-mesons brought to rest in matter eventually disappear, either by spontaneous decay or by nuclear capture. In either case the process takes place in two fairly distinct steps. First the meson is attracted into quantum orbits around a nucleus, to which it is bound by the electrical forces. During this stage it emits X-rays or ejects atomic electrons as it jumps successively from one quantum state to another, until it reaches the state of lowest energy. Disintegration or capture then occurs. The orbits are like those of the interior atomic electrons, but about two hundred times smaller in linear dimensions (a consequence of the greater mass of the meson). The energy of the X-rays is similarly some two hundred times greater than the corresponding atomic X-rays. Rainwater and Fitch have observed these X-rays and made precise determinations of their energies. Since the deepest meson orbit and the nucleus are comparable in size for a heavy nucleus, the energy of the former is strongly influenced by the way in which electric charge is distributed in the nucleus. From their measurements Rainwater and Fitch conclude that the charge is considerably more concentrated towards the centre than had been previously believed. They deduce an *effective* radius 15 per cent smaller than is yielded by such methods as nuclear binding energies or neutron scattering.

Industrial Application of Aerodynamic Techniques

A NUMBER of special applications of aerodynamic equipment and techniques which have been used in the course of investigations in the Aerodynamics Division of the National Physical Laboratory, Teddington, are described in a little handbook entitled "The Industrial Application of Aerodynamic Techniques" (National Physical Laboratory: Notes on Applied Science No. 2. Pp. 37. London: H.M.S.O., 1952. 3*s*. 6*d*. net). It is often impossible to use the wind tunnel for the solution of problems of fluid motion which arise outside the aircraft industry. Dr. R. A. Frazer's work on the aerodynamic stability of suspension bridges is an exception, and the model tests done for the Severn Bridge project are described. Civil and mechanical engineers will deduce without surprise that there are few industrial applications of text-book aerodynamics. This is, of course, true; but one feels that opportunity has been lost by conveying a too sober estimate of the possibilities of applying aerodynamic experience to industrial practice.

Kodaikanal Observatory: Report for 1950

THE report for 1950 of the Kodaikanal Observatory (pp. 8; Delhi: Manager of Publications, 1951; 7 annas or 8*d*.) deals chiefly with the astronomical work there, though short references are given to geomagnetic observations and seismology; the meteorological data appear in the *Indian Weather Review*, and the administrative details in the annual report of the Indian Meteorological Department. A list of the forty-seven instruments in use is given and also a brief account of the constructional works relating to development projects, including the construction of a dome for housing a 20-in. Grubb reflector and of buildings for an ionosphere laboratory. There has been a considerable amount of co-operation with other observatories—the Solar Physics Observatory, Cambridge, the Royal Greenwich Observatory, the Meudon Observatory, and the Mt. Wilson Observatory—with which there has been exchange of spectroheliograms, photoheliograms, quarterly statements of solar flares, etc. During 1950 the Government of India granted two research scholarships in astronomy tenable for three years at the Kodaikanal Observatory.

Beit Memorial Fellowships for Medical Research

BEIT Memorial Fellowships for medical research have been awarded as follows. *Fourth Year Fellowship* (£735 a year): Dr. Joan E. Keilin (University of Cambridge), to investigate, at the Department of Biochemistry, Cambridge, the catalytic activity of hæmatin compounds and the effect of oxidizing agents on hæmatins, the properties of purified helicorubin and its relationship to other natural hæmoproteins, and the reactions of hæmatins with proteins and their constituent amino-acids and peptides, with the aim of gaining more information on the structure of the hæmoglobin molecule, the link between the hæm and globin and the use of hæmatin as a reagent for the study of other biologically important proteins. *Junior Fellowships* (£630 a year): J. R. Cannon (University of Sydney), to continue at the University Chemical Laboratories, Cambridge, the study of the chemical structure of vitamin B_{12}; G. P. Lewis (University of Wales), to study, at the National Institute for Medical Research, Mill Hill, London, the relationship between structure and action of drugs, particularly of antagonists of histamine, acetylcholine, adrenaline and *nor*-adrenaline, in order to examine how far ionization of a drug or its receptor modifies drug action; W. L. Nicholas (University of Liverpool), to investigate, at the Department of Zoology, Liverpool, the determination of the growth requirements of free-living and parasitic nematodes in chemically

defined media, with the view of its possible application to the chemotherapy of nematode infections; Dr. Evelyn E. B. Smith (University of Glasgow), to investigate, at the Department of Biochemistry, Glasgow, the enzymic mechanisms of transfer reactions involving uridine pyrophosphate compounds containing glucose, glucuronic acid and N-acetylglucosamine, and to study the biosynthesis of glucuronic acid, glucuronides and oligosaccharides containing glucuronic acid, using carbon and phosphorus isotopes.

Lady Tata Memorial Trust: Awards

The following awards have been made by the Lady Tata Memorial Trust for research on leukæmia and allied diseases, to be conducted in the places indicated during the academic year beginning October 1, 1953. *Grants for research expenses or for scientific assistance:* Dr. A. Fagraeus and Dr. B. Thorell (Stockholm), Dr. C. Merskey (Cape Town), Prof. C. Oberling (Villejuif, Seine) and Dr. C. C. Ungley (Newcastle upon Tyne), renewals; Dr. J. Nordmann (Paris), new award. *Part-time personal grant and grant for technical assistance:* Dr. J. B. G. Dausset (Paris), renewal with increase. *Senior Research Fellowships:* Dr. A. R. Gopal-Ayengar (London), extension for two months; Dr. J. Kieler (Copenhagen), new award. *Scholarships (whole-time or part-time):* Dr. R. Rask-Nielsen (Copenhagen) and Dr. R. Robineaux (Paris), renewals; Dr. F. Kissmeyer-Nielsen (Aarhus) and Dr. N. A. Stenderup (Aarhus), new awards. In addition, the period of tenure of a special scholarship awarded earlier this year to Dr. Gavino Negroni (Italy), for work at the Imperial Cancer Research Fund Laboratories, Mill Hill, London, will continue until April 30, 1954.

University of Birmingham: Appointments

The following have been appointed lecturers in the University of Birmingham: Dr. J. H. Cort (physiology), Miss Joyce B. Grace (bacteriology), Dr. T. O. Jeffries (physics), J. B. Woodward (mathematical physics) and Dr. K. White (physiology). The following have resigned from the University: F. R. N. Nabarro, lecturer in metallurgy, on appointment to the chair of physics in the University of the Witwatersrand, Johannesburg; and Dr. A. B. L. Beznak, lecturer in physiology, on appointment to the chair of physiology in the University of Ottawa.

American Academy of Arts and Sciences: Foreign Honorary Members

The following have been elected foreign honorary members of the American Academy of Arts and Sciences: Prof. Arne Tiselius, professor of biochemistry, University of Upsala; Prof. A. J. Kluyver, professor of microbiology, Technical University, Delft; and Prof. D. M. S. Watson, formerly Jodrell professor of zoology and comparative anatomy, University College, London.

Meeting of Nobel Prize-winners in Lindau

Meetings of Nobel prize-winners were started some years ago at Lindau, Bavaria, on the shores of Lake Constance, for the purpose of creating and developing a general contact between leading scholars in an exact science and the professional and industrial workers whose daily work is based on the results of the investigations of these scientists. The method chosen for achieving this contact is for the Nobel Laureates to give lectures adapted in their content to the needs of practical men and giving a survey on the results of scientific research to the layman. The meeting this year, to be held during June 29–July 2 under the patronage of Count Lennart Bernadotte, is devoted to physics, and eight lectures will be given as follows: June 29, Prof. M. von Laue (Röntgen-ray interferences) and Prof. G. von Hevesy (biochemical effects of ionizing radiations); June 30, Prof. O. Hahn (modern alchemy) and Prof. C. F. Powell (high-altitude flights with free balloons); July 1, Prof. F. Soddy (discovery of the natural transmutation of the radio-elements) and Prof. P. A. M. Dirac (quantum mechanics and the æther); July 2, Prof. H. Yukawa (search for a unified theory of elementary particles) and Prof. W. Heisenberg (progress and difficulties in the quantum theory of elementary particles). The general arrangement is for lectures to be given during the morning so as to leave the rest of the day free for discussion groups and for excursions and other social activities. The fee for participation in the meeting is DM 30 or DM 10 a day. Further information can be obtained from the Sekretariat der Tagungen der Nobelpreisträger, Stadttheater, Lindau-Bodensee.

Announcements

Dr. L. C. Bateman, deputy director of research and formerly superintendent of chemical research of the British Rubber Producers' Research Association, has been appointed director of research of the Association in succession to Dr. Geoffrey Gee, now professor of physical chemistry in the University of Manchester.

Dr. Ernst Mayr, curator of the Whitney–Rothschild Collection, American Museum of Natural History, has been appointed Alexander Agassiz professor of zoology in the Museum of Comparative Zoology, Harvard University. Two other appointments are those of Mr. James C. Greenway, jun., to be curator of birds in the Museum in succession to the late James L. Peters, and Mr. Raymond A. Paynter, jun., to be assistant curator of birds.

The Philosophy of Science Group of the British Society for the History of Science is offering a prize of £50 for the best essay of not more than 4,000 words on: "What is the logical and scientific status of the concept of the temporal origin and age of the Universe?" (for example, as used in recent cosmological work). The essay should clarify the logical, theoretical, and observational aspects of the idea of assigning a quantitative age to the universe. Essays in English, French or German (in typescript) must reach the Honorary Secretary, Philosophy of Science Group, University College, Gower Street, London, W.C.1, not later than December 1, 1953, must bear a pseudonym, and be accompanied by a closed envelope containing the pseudonym and the author's name. Essays submitted will be treated as material offered to the *British Journal for the Philosophy of Science*.

Errata. In the article entitled "Food Products from Plants" in *Nature* of May 23, p. 917, paragraph 3, line 3, for "0·069*d.* per lb. of protein, compared with 0·8*d.* per lb. of protein from beef", read "0·069*d.* per gm." and "0·8*d.* per gm.", respectively.

ENGINEERING IN THE UNIVERSITY OF NOTTINGHAM

OPENING OF LABORATORY EXTENSIONS

THE original engineering laboratories of University College, Nottingham, as it then was, were completed in 1930, and until 1948, apart from a small extension of drawing-office accommodation, no further expansion was made. In 1930 the number of full-time students was 17, a number which by 1940 had increased to 44, and by 1946 (the date of the Barlow Report) to 128. In 1950 there were approximately two hundred students reading for degrees in engineering; this number was really far in excess of the facilities at the University's disposal, and adequate training was only given by running dual streams of undergraduates in each year. Such conditions could only be tolerated for a short time to meet a national emergency, and a further demand on accommodation was made when, on the University receiving its charter in 1948, it became possible to develop further the research schools in applied science.

The University was faced with the preparation of a long-term scheme for the development of technology, or of putting into operation a smaller scheme which would bring relief with the shortest possible delay. The first scheme would certainly have taken six years to plan and complete, and in this time the intake of applied science students would have had to be reduced. This seemed contrary to the national interest, and so it was decided to proceed with the smaller project which could be completed in a little more than two years, during which time the student numbers could be maintained and active research schools developed. The project has now been completed, the immediate extra accommodation provided by the extensions representing an increase of some 60 per cent; when rooms at present loaned to the Arts Faculty are available, the total increase of accommodation will be 80 per cent, making possible an intake of students at the rate of ninety a year.

The extensions to the laboratories were opened on April 14 by Lord Hives, chairman and joint managing director of Rolls Royce, Ltd. Lord Hives pointed out that, although society to-day is increasingly dependent on the achievements of applied science, too few of the present-day university students in Britain study this vital subject—only a sixth, in fact, of the 72·5 per cent at universities who are in some measure or other assisted financially by the State. That the percentage of technological students is so small is causing both educationists and industrialists much anxiety, and Lord Hives noted with satisfaction that Nottingham anticipated some time ago the increase in the facilities required for training.

In Lord Hives's opinion, the reason for the unsatisfactory state of recruitment is not to be found at the level of the university, but is something much deeper: it is to be found in the schools and in the attitude of mind of a great number of the parents in Britain. Since engineering, even in its fundamentals, is not taught in schools, too often when a boy comes to consider what he should study at the university, or what career to take up straight from school, he knows nothing at first hand of one of his country's greatest possible careers—engineering.

A distinguished careers master, Mr. Howard Ruby, of Dulwich College, put the position very neatly when he wrote recently that even when careers masters are well aware of the good prospects in an industrial career, their problem is to convince parents and boys, for there still survives in the minds of some parents the view that a career in industry is not so respectable as one in the Armed or Civil Services or other professions. Such a point of view is not only out of date but also harmful, and so long as it persists Britain will never have the skilled men that it requires. A unique place in the estimation of the world has been earned for Britain by its craftsmanship, the skill of its engineers and technicians and the ingenuity of its scientists, and it is necessary that young men should come forward in increasing quality and numbers for past triumphs to be maintained and even exceeded. The main lesson to be learnt from the United States is the high position in society given to industry in that country. As one of the recent Anglo-American productivity teams said in its report: "It is because of this social and intellectual prestige attaching to the highest position in industry that many of the best students choose industry for a career". Lord Hives emphasized the fact that in the engineering industry many of the key positions at the very top of the tree are held by trained engineers. In fact, there is no better training for an executive in the industry to-day than to have worked in his time as a skilled engineer. Yet to many people engineering is still something 'messy', something that polite young men ought not to get mixed up in. Technical engineering, on the other hand, can be the most exciting and fascinating way of earning a living, and the chief reason for this is that it can never remain static.

Prof. J. A. Pope, head of the Department of Civil and Mechanical Engineering in Nottingham, thanked the University Grants Committee and members of industry who through their generous support had made the developments possible, and paid tribute to the University surveyor, Mr. J. W. Popplewell, and his staff on achieving a useful and economical design of building; the capital expenditure per student place had been kept very low without any sacrifice of student amenities or teaching efficiency.

BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

RESIDENTIAL CONFERENCE

THE first residential conference of the British Gelatine and Glue Research Association was held at Hulme Hall, University of Manchester, during April 8–11, and the progress made in the first two and a half years of research work was reported. The meeting was well attended, those present including representatives of gelatine and glue manufacturing firms, of firms using these products, and of government laboratories, research associations and university departments.

The Conference Lecture, by Dr. G. R. Tristram (University of St. Andrews), reviewed recent progress

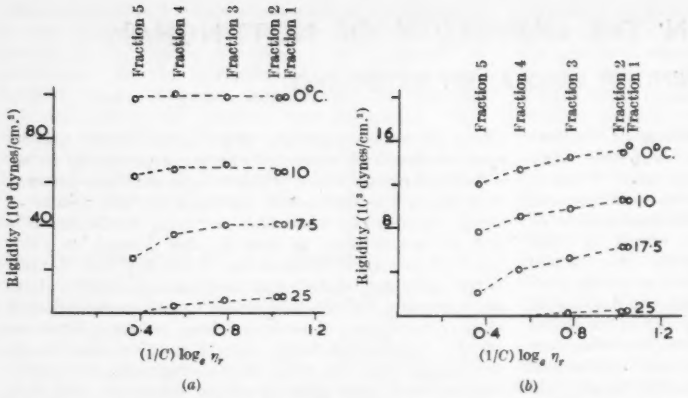


Fig. 1. Rigidity of gels from fractions of gelatin as a function of reduced viscosity (C = 0·2 per cent) at temperatures from 0°–25° C. in 1 M sodium chloride at pH 7: (*a*) gel concentration 5·5 per cent; (*b*) gel concentration 2·2 per cent

in protein research. The techniques by which the amino-acid composition, N-terminal and C-terminal residues, and amino-acid sequence might be determined were given, and illustrated by F. Sanger's work on insulin. Although adequate to give the structure of insulin, which is a protein of comparatively low molecular weight, existing techniques appear inadequate for obtaining the sequence in proteins of higher molecular weight, and still more so for heterodisperse systems such as gelatin.

One of the principal raw materials of the industry was considered by Dr. J. E. Eastoe, in a paper on the composition of bone. The tissue selected for study was a powdered sample of compact bone from the central, tubular portion of the femur of the cow, since it could be obtained almost entirely free of other tissues. The organic components of the tissue were collagen (18·64 per cent), mucopolysaccharide (0·24 per cent), and a protein which resisted solution in boiling water (1·02 per cent). Free sugars were not detected, nor was fat present. Inorganic matter, with which citrate was included, made up 70·91 per cent, and with water (8·18 per cent) gave a total of 99·0 per cent. No significant chemical differences were observed between the bone collagen and hide or sinew collagens. The mucopolysaccharide contained some 70 per cent of a protein of amino-acid composition similar to blood albumin, while the carbohydrate portion did not correspond to published compositions[1] for chondroitin or mucoitin sulphate. Glucos-2-amine, galactos-2-amine, glucuronic acid, galactose and mannose were all detected in the carbohydrate, and they were estimated approximately. The resistant protein was shown to be neither collagen nor elastin.

Mr. D. Fysh gave a short paper describing the equipment being used for empirical studies of the extraction of bone glue. Preliminary results indicate the relative importance of the two stages—heating under steam pressure, and addition of hot water to give the glue liquor—in the extraction process.

The remaining papers were concerned with the properties of gelatin, which had been chosen as the main field of study. Dr. G. Stainsby described a new technique[2] for fractionating gelatin, using the solubility of the complex formed between gelatin and sodium dodecyl sulphate. The method makes extensive use of the work of Smith and Pankhurst[3,4] concerning the behaviour of the complexes. Successive raising of the salt concentration in a solution of gelatin and sodium dodecyl sulphate at 35° C. and pH 7 causes portions of the complex to separate as a coacervate. Material of high molecular weight is separated off at the lower salt concentrations. By acetone precipitation, the gelatin present in the coacervate may be separated from the sodium dodecyl sulphate and its properties measured. A very simple procedure involving the preparation of five fractions has proved adequate to show differences in the distribution of molecular weight between closely related gelatins.

P. R. Saunders reported on the properties of the gelatin fractions. Contrary to results obtained by J. D. Ferry for unfractionated materials of differing molecular weight[5], the molecular weight of a gelatin fraction has been shown to be of importance in determining the rigidity of a gelatin gel, only as the temperature approaches the melting point or the concentration is lowered to a point at which weak gels alone are formed. The method used for rigidity measurements[6], involving the deformation of a cylinder of gel, set in a precision-bore tube, under air pressure, was sufficiently simple to enable measurements to be made at two concentrations and four temperatures (0–25° C.) for fractions of six gelatins of widely differing types. The results for one gelatin are shown in Fig. 1. It can be clearly seen that at 0° C. and 10° C. the rigidity (5·5 per cent concentration) was independent of the reduced viscosity ($1/C$ log$_e$ $\eta_{rel.}$, in 1 M sodium chloride, pH 7) and hence of molecular weight. Confirming results by Pouradier[7], it has been shown that the melting point of gelatin does not depend solely on molecular weight. The viscosity of fairly concentrated solutions has been shown to be uniquely related, within the rather large experimental error, to the dilute solution viscosity.

Dr. A. Courts showed how the fluoro-dinitrobenzene technique of F. Sanger[8] can be used to determine the N-terminal amino-acid residues of gelatin and its degradation products. Typical figures for gelatin prepared from an alkali-treated calf-skin precursor and an acid-process pigskin gelatin are given in Table 1.

Table 1

	N-terminal residues of gelatin (gm./100 kgm. gelatin)	
	Calfskin	Pigskin acid process
Glycine	0·83	0·74
Serine	0·19	0·10
Threonine	0·11	0·08
Alanine	0·11	0·24
Aspartic acid	0·11	0·13
Glutamic acid	0·10	0·07
Others	0·12	0·19
Total	1·57	1·55
Isoelectric point (pH)	5·1	9·4

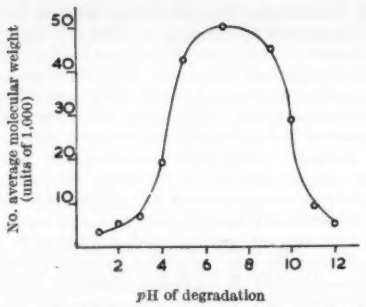


Fig. 2. M_n of gelatin (M_n initial = 58,000) after heating in solution for 24 hr. at 75° C.

The examples quoted in Table 1 were selected to give almost the same total of end-groups, to assist in comparison.

The number of N-terminal residues may be used to give the number-average molecular weight (M_n) for the gelatin sample, if it is assumed that the gelatin molecule is a single polypeptide chain with one N-terminal residue per molecule. The values of M_n obtained for alkali-processed gelatins were 50,000–70,000, which is in fair agreement with osmotic determinations by Pouradier[7] for similar gelatins.

A number of samples of a gelatin, which gave $M_n = 58{,}000$ by fluoro-dinitro benzene technique, were degraded at 75° C. for 24 hr. at 5 per cent concentration at different *p*H's. The effect on the values of M_n is shown in Fig. 2. The curve is nearly symmetrical about *p*H 7. Further experiments at different temperatures suggest a figure of 19,000 cal. for the mean activation energy for breaking peptide bonds, as measured by the release of N-terminal residues. This figure is in quite good agreement with values deduced[8] from the viscosity and other properties.

A. W. Kenchington presented a paper on the methylation of gelatin, and on the means by which the degree of substitution can be estimated when gelatin is modified by organic reactions. The most important method, giving values for several groups, makes use of the titration curve. Provided the isoelectric point is also known, the titration curve can be used for giving values for carboxyl, imidazole, ε-amino and guanidino groups. The proportion of the dicarboxylic acids in the amide form can also be deduced. By analysis of the curves obtained for gelatin samples, the limits of titration suggested by Cannan[10] have been modified, so that at 40° C. they are :

TABLE 2

	New values	Cannan's values
Carboxyl groups	*p*H 1·5–6·5	*p*H 1·5–6·0
α-Amino and imidazole	*p*H 6·5–8	*p*H 6·0–8·5
ε-Amino	*p*H 8–12	*p*H 8·5–12·5
Guanidino	not titrated	*pK* presumed > 12

The use of these limits secures agreement between figures for the grouping by analytical and titration-curve methods. The need for the changes results from the following : (i) the presence of a substantial proportion of hydroxylysine ; (ii) the higher temperature of measurement reduces the *pK* of the ε-amino group ; (iii) some proportion of the carboxyl groups have *pK*'s in the region of *p*H 5, and their contribution will only become small above *p*H 6·5.

Methylation has been carried out by a slow reaction with methanol under acid conditions. Although almost complete methylation of carboxyl groups was achieved, a proportion of the esterified groups is very unstable, and readily loses methanol. Up to 33 per cent substitution, the derivative appears stable to most conditions, but not to alkalis. The degree of substitution was measured using a modified Zeisel method, and the values agreed well with the number of carboxyl groups no longer titratable in the titration-curve method. This suggests that no methylation of hydroxyl groups has taken place. There was also no evidence of methylation of the ε-amino groups. The methylated gelatin was not very different in general behaviour from its parent gelatin and gels were easily obtained. Some degradation had occurred, probably due to the low reaction *p*H.

E. Courtman outlined a method for determining total bacterial counts for gelatine. Wide variations of total count are known to occur for samples withdrawn from a single gelatine batch[11,12], which result, it would appear, from high local concentrations of bacteria in individual grains. The expression of results as a mean with limits of error will assist in preventing needless disputes over disagreeing values.

M. E. Adams reviewed the manifold uses of gelatine and glue. By classification according to relevant properties, she was able to show that problems of the interface represent the largest gap in knowledge of gelatine and glue.

A. G. Ward, director of research of the Association, in the concluding paper of the conference, outlined the present knowledge of gelatin and its preparation from collagen. The structural features of gelatin which determine the properties of its solutions and gels appear to be, in the main, charge distribution arising from the ionizable groups, molecular weight and molecular weight distribution, and some third factor which affects the rigidity of gels, particularly at low temperatures. This third factor also appears to influence the melting point and the point at which alcohol gives turbidity to a gelatin solution[7]. Little is known of the changes involved in converting collagen to gelatin, but the techniques now available will assist in studying this problem. In addition to these subjects, the Association will in the next five years use empirical methods both for problems of manufacture and for user problems, and also examine in a more fundamental way the behaviour of gelatin at the liquid–gas, liquid–liquid and liquid–solid interfaces. This behaviour is of importance in many uses of gelatine and glue.

A. G. WARD

[1] Stacey, M., "Adv. Carbohydrate Chem.", **2**, 161 (New York : Academic Press, Inc., 1946).
[2] Stainsby, G., Saunders, P. R., and Ward, A. G., Proc. 13th Int. Cong. Pure and Applied Chem., Uppsala, 1953 (in the press).
[3] Pankhurst, K. G. A., and Smith, R. C. M., *Trans. Farad. Soc.*, **43**, 6 (1947).
[4] Pankhurst, K. G. A., "Surface Chemistry" (*Research* Supp.), 109 (London : Butterworth, 1949).
[5] Ferry, J. D., *J. Amer. Chem. Soc.*, **70**, 2244 (1948).
[6] Saunders, P. R., and Ward, A. G., Proc. 2nd. Int. Conf. Rheology (London : Butterworth) (in the press).
[7] Pouradier, J., and Venet, A. M., *J. Chim. Phys.*, **49**, 85 (1952).
[8] Sanger, F., *Biochem. J.*, **39**, 507 (1945).
[9] Sheppard, S. E., and Houck, R. C., *J. Phys. Chem.*, **36**, 2319 (1932).
[10] Cannan, R. K., *Chem. Rev.*, **30**, 395 (1942).
[11] Tech. Comm. Edible Gelatin Manuf. Res. Soc. Amer., *Food Research*, **8**, 429 (1943).
[12] Johns, C. K., *Food Research*, **16**, 281 (1951).

CROP PROTECTION

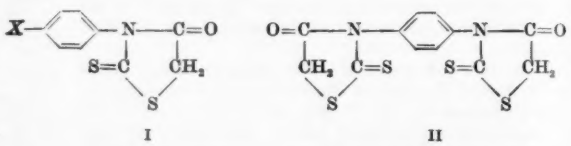
SYMPOSIUM IN GHENT

THE annual symposia on crop protection, held at the College of Agriculture, Ghent, have attracted larger numbers each year since the present rector of the College, Prof. J. Van den Brande, organized the first meeting in 1948, and at the meeting this year, held on May 5, some two hundred and fifty persons participated. Although the majority were from Belgium and Holland, representatives from several other countries were present. The opening address by Prof. Van den Brande in the morning was followed by two simultaneous sessions for the reading of papers, and during the afternoon a further five papers were read.

Dr. J. G. ten Houten (Wageningen) gave an excellent general survey of the research now proceeding in the Netherlands on plant diseases and pests and their control. In the work on apple scab, the correlation between temperature and duration of wetting of apple leaves in relation to the primary infection and incubation periods for *Venturia inæqualis*, as established by Mills in the United States, has been confirmed under the climatic conditions prevailing in the Netherlands. By spraying eradicant fungicides (organo mercury compounds) up to five days after infection took place, it was possible to control apple scab by only three sprayings against the six required with protective fungicides like lime sulphur. Spraying with organo mercury compounds, however, can only be used on non-susceptible apple varieties, and such treatments should not be made after ascospore discharge has ceased. Research on the Rubus stunt virus of raspberries has shown that diseased shoots can be completely freed from the virus by immersion in water at 45° C. for 1–3 hours. Excellent control of the pea moth (*Enarmonia nigricana*) attacking canning and other peas which are harvested early has been consistently obtained by one application of parathion when the lower pods are about three-quarters grown. Toxicological trials indicate little consumer hazard if the recommended procedure is adopted. The potato root eelworm (*Heterodera rostochiensis*) is a serious pest in Holland, and to grow potatoes in infested soils or to take a potato crop more than once every three years from non-infested soil is prohibited by law. A team of research workers is concerned with the control of this pest. The investigations include soil treatment with chemicals, finding the substances in potato root extracts responsible for the hatching of the cysts, the possibility of using parasites (fungi and a newly found amœba), and breeding resistant potato varieties. The control of cyst-forming eelworms with 'DD mixture' was the subject of a paper by Dr. J. Th. W. Montagne (Amsterdam), in which he said that soil treatment with the chemical combined with a short crop-rotation has been found to give the best results. Prof. Van den Brande, R. H. Kips and J. D'Herde (Ghent), also studying the eelworm problem, described how they had examined some of the newer systemic insecticides for nematocidal action. Again, Dr. M. Oostenbrink and Dr. A. F. H. Besemer (Wageningen) showed that a root rot disease in chrysanthemums, pyrethrums and other flowers grown for cutting is associated with parasitic eelworms. Large numbers of *Meloidogyne* sp. and *Pratylenchus* sp. were present in the sick fields, and it had been shown that attack by these pests was a primary cause of the disease, the fungus attack probably leading to the final collapse of the root. Soil fumigation with chloropicrin gave the most effective control.

Several papers were concerned with weed control. M. Slaats and J. Stryckers (Ghent) showed that under certain conditions ammonium dinitro-*o*-cresylate can be used for controlling weeds in hybrid maize; hormone-type weed killers damage the crop. Dr. F. H. Feekes (Baarn) discussed his work on the use of *iso*propyl-N-phenyl carbamate and sodium *iso*propylxanthate as selective weed killers. A striking control of chickweed (*Stellaria media*) was achieved with the former substance at 10 lb. an acre.

Dr. G. J. M. Van der Kerk (Utrecht) described a new group of organic fungicides which has arisen from his work on dithiocarbamic acid derivatives. These compounds are the N-phenylrhodanines with *para* substituents in the benzene ring (I). The most active compound so far obtained is *p*-phenylene-*bis*rhodanine (II), which, against the four fungi tested, is at least as fungicidal as the most active of the dithiocarbamic acid derivatives now used in crop protection.



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Another paper concerned with fungicides was presented by L. Bravenboer (Naaldwijk), who discussed his attempts to correlate the degree of control of *Cladosporium cucumerinum* obtained in practice with the results of laboratory experiments. Prof. R. L. Wain (London) reviewed the present position of systemic fungicides; he gave an account of the more recent British and American work in this field and described the investigations being carried out in his department with aryloxyalkylcarboxylic acids and other compounds. M. J. Zwijns (Maarssen), in discussing seed disinfectants, said that tetramethylthiuram disulphide has given excellent results as a seed dressing for beets, beans, peas, corn, flax and other crops; 2 : 3-dichloro-1 : 4-naphthoquinone and tetrachloro-1 : 4-benzoquinone have also proved satisfactory. R. Bovigne *et al.* (Gembloux) outlined the results of experiments using tetrachloronitrobenzene, methylnaphthyl ethyl ether, methyl α-naphthylacetate and *iso*propyl-N-phenyl carbamate for preventing the sprouting of potatoes. Dr. H. Franke-Grosmann (Reinbek-Hamburg) gave an interesting account of how the gall mite *Aceria gemmarum* (Nalepa) became a serious pest on willow following the use of DDT and BHC against leaf-eating beetles and weevils (*Phyllodecta vulgatissima* and *Pselaphorhynchitis* spp.); much damage was caused in *Salix viminalis f. regalia*, whereas *S. americana* was attacked to a much less extent.

Other topics discussed were the value of the Fischer index as a means of estimating the keeping qualities of suspensions (P. H. Martens and J. Henriet, of Gembloux), the control of the cabbage seed-pod weevil with BHC and parathion (Prof. J. H. Schuurmans-Stekhoven, of Deventer), experience in the Netherlands with new types of acaricides

(A. F. H. Besemer and K. Hartsuyker, of Wageningen), a new method of applying pest control materials to plants (Prof. P. Froeschel, of Ghent) and a biological method for assessing residual parathion on cabbage leaves (Dr. J. J. Fransen, of Arnhem).

The organizers are to be congratulated on the satisfactory arrangement and smooth running of this successful symposium. R. L. WAIN

RESEARCH IN RURAL ELECTRIFICATION

WORK AT THE ELECTRICAL RESEARCH ASSOCIATION

AN open week, beginning on May 4, was held at the Field Station at Shinfield, near Reading, of the Electrical Research Association, and Mr. G. R. H. Nugent, parliamentary secretary of the Ministry of Agriculture and Fisheries, a Ministry which makes a substantial contribution to the work of the Association, officially inaugurated the proceedings.

The Electrical Research Association established its Rural Electrification Section in 1938 with the main object of developing equipment and operating techniques which are satisfactory to the farmer or grower and which, at the same time, present load characteristics favourable to the economic supply of electricity. The larger the energy taken by rural consumers, especially during off-peak periods, and the lower the power demand, the greater the possible economy. Mr. Nugent emphasized the benefit of electricity on the farm, especially in saving labour and thus increasing production with the present labour force, and also in providing amenities for farm workers to encourage them to stay on the land rather than to succumb to the attractions of the town. A large, and rapidly increasing, number of farms now have electricity, but too many of them fail to make full use of it. Although electric light and domestic power are certainly valuable, much fuller advantage should be taken of electrical methods in agriculture and horticulture. The Ministry, said Mr. Nugent, is fully in agreement with the aims of the research work at Shinfield; economic considerations are rightly kept to the fore in the development of new applications of electricity on the farm.

At the Field Station, basic research determines the form of equipment and the technique required for electrical operation. This is followed by full-scale tests and later by trials under practical conditions on farms and horticultural holdings in different parts of Britain. The co-operation of the agricultural research establishments and of farmers and growers is an essential feature of work of this kind, and the Association has been fortunate in obtaining such co-operation both from its neighbours—the University of Reading and the National Institute for Research in Dairying—and from others much farther afield.

The underlying principle in many of the investigations is simplicity of operation, with electrical methods involving low kilowatt loadings which can be used for a lengthy period. These are much more welcome to electricity supply than the high short-period loads which present difficult problems in rural electrification.

A number of researches already completed have formed the basis for equipment which is now commercially available. Among these are: barn hay-drying, a method of producing very high quality hay by blowing cold, or slightly warmed, air through grass stacked in the barn; a low-powered automatic hammer mill for farm grinding; a soil sterilizer of the immersion type for potting soil; and soil warming in frames and glass-houses by a simplified method in which a daily 'dose' of energy provides beneficial soil warmth but avoids the large consumption needed to maintain a suitable fixed temperature. Work now in progress on the horticultural plots aims at further improvement of the soil-warming technique and at finding the crops and varieties for which it is most likely to be economical in frames, under cloches and in open ground.

In the glass-houses, electric space-heating is used in combination with soil-warming, and different arrangements and forms of construction are being studied to reduce heat losses and so to minimize operating costs. Artificial illumination, using various kinds of lamps and of lighting fittings, is being applied to the raising of tomato seedlings. Laboratory work on soil sterilization by the electrode method, in which current is passed directly through the soil, is preliminary to *in situ* sterilization of glass-house soil. A model glass-house in the exhibition was fitted with many devices which may be developed in future for the complete control of all the factors involved in growing plants to perfection. Presuming that the plant physiologists achieve their goal, this is the ultimate object of the researches now in progress.

Laboratory work on the agricultural side is concerned with the requirements for drying many kinds of agricultural materials and with their equilibrium moisture content in different atmospheric conditions. Grain drying, grass drying and seed drying are studied experimentally, and a novel form of moisture-meter for grain has been developed. A 'farm of the future' in the display showed many new agricultural applications of electricity which, in combination with existing ones, could be used to provide an approximately constant load throughout the year. They would both save labour and give a high load-factor on the farm.

An electrically driven tractor which has been used for the cultivation work at the Field Station during the past three years has the advantages of simple and quiet operation, low running and maintenance costs, and ample tractive effort over a wide range of speeds.

In conjunction with the University of Reading poultry farm, investigations are being made on the possibilities of electrical methods in poultry husbandry. These include air-conditioning for laying hens, the effect of environment on the growth of chicks, and flash illumination in laying-houses as an energy-saving alternative to the usual artificially extended daylight. The destruction of pests by the use of high-frequency fields, the killing of weeds by an electrical discharge and fish-stunning by passing a current through the water in streams or in the sea, are other subjects studied. An experimental heat pump is used for heating one of the laboratory buildings, and its performance is being tested by comparison with that of a conventional plant in another building with similar thermal characteristics. The heat-pump principle is also being applied to dairy work with the object of using heat removed from milk in cooling it to heat water for washing.

Another display showed something of the researches of the Association on the possibilities of wind-power for electricity generation on different scales of use. A survey, for which several new measuring instruments have been developed, is in progress in western coastal areas of Great Britain and Ireland. Many specially favourable sites have been found, and pilot plants, of 100-kW. capacity, are being built in Orkney and for another site. The performance will be tested as a guide to the design of larger machines for which a basis has already been formed by comprehensive design and costing studies. At the same time, the study includes the design, development and use of smaller plants adapted to typical isolated communities in Britain and abroad where adequate alternative sources of power are difficult to come by. For topical interest, the actual record was displayed of the highest wind-speed yet recorded in the British Isles, namely, 125 m.p.h. on Costa Hill, Orkney, early this year.

LATTICE DEFECTS AND THE ELECTRICAL RESISTIVITY OF METALS

An informal conference arranged by the Department of Metallurgy, University of Birmingham, and concerned with recent work on the influences of deformation and irradiation on the electrical properties of metals, was held in Birmingham during April 24–25.

Following an introductory survey by T. Broom (Birmingham), which served to enumerate some present-day problems, J. A. Manintveld (Delft) presented new results for the recovery of resistivity of pure metals after heavy deformation at low temperatures. There is general agreement that a well-defined recovery process occurring at around 0° C. is due to the movement of single vacancies; but a satisfactory account of recovery at lower temperatures is lacking. Prof. M. J. Druyvesteyn (Delft) discussed possible processes for this and also gave results of an investigation into recovery of mechanical properties of polycrystalline wires after low-temperature deformation.

Various mechanisms for the generation of vacancies and interstitial ions during deformation were critically reviewed by Prof. N. F. Mott (Bristol), and one of these, the intersection of screw dislocations, was used by H. G. van Bueren (Eindhoven) as a basis for a theoretical treatment of resistivity-extension curves in which a three-halves power law is obeyed. P. Jongenburger (Eindhoven) completed the discussion of vacancy effects in pure metals by describing his calculations of scattering due to single vacancies in copper, silver and gold.

A new theoretical treatment by S. C. Hunter and Dr. F. R. N. Nabarro (Birmingham) of the resistance due to screw and edge dislocations in metals was presented and the need for a calculation of scattering from stacking faults was pointed out. Predictions of anisotropic scattering from single dislocations formed the basis of an account given by C. W. Berghout (Delft) of some experiments on the anisotropy of resistivity of plastically stretched foils. J. F. Nicholas (Melbourne) gave results of an investigation into the validity of Matthiessen's rule for cold-worked metals and alloys and put forward a qualitative interpretation of the small deviations found.

Resistance changes due to the irradiation of pure metals and the ordered alloy Cu_3Au by electrons, neutrons, deuterons, etc., were discussed by R. A. Dugdale (Harwell). As in deformation studies, recovery experiments reveal effects almost certainly due to the diffusion of vacancies, and indeed recent work at Harwell on Cu_3Au has shown very similar activation energies for recovery of resistivity measured after irradiation, after quenching and after cold-working.

Dr. K. Lücke (Göttingen) reviewed the influence of impurities in copper on the results of deformation and recovery experiments and also gave an account of work on resistance changes in iron due to strain-ageing. Two contributed papers dealt with resistance changes in alloys: Dr. W. H. Aarts and R. K. Jarvis (Johannesburg) reported increases of resistivity during room-temperature annealing of some silver–gold alloys following deformation at low temperatures; Dr. J. O. Linde (Stockholm) wrote giving the results of a study of the effect of deformation on the resistivity of certain binary, ternary and quaternary alloys of silver and gold with transition metals. Finally, J. F. Nicholas (Melbourne) pointed out the lack of any direct experimental or theoretical evidence for the supposition that large resistivity changes caused by the deformation of some alloys are due to the destruction of short-range order.

Many interesting points were raised in discussion and served to reveal the utility of resistivity studies as a means of investigating the structure of metals.

T. Broom

CROSSED AMORPHOUS AND CRYSTALLINE CHAIN ORIENTATION IN POLYTHENE FILM

By D. R. HOLMES, R. G. MILLER, R. P. PALMER and C. W. BUNN

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The structure of polythene film has been investigated by X-ray, optical and polarized infra-red methods. It was found that the polymer chains are oriented differently in the crystalline and the amorphous regions, the respective chain axes being perpendicular to each other. We are unaware of any previous investigations into the orientation in both crystalline and amorphous regions, and as a result this remarkable phenomenon has escaped notice.

Most polythene film is produced by extruding the viscous molten polymer through a slit, passing the resulting sheet downwards into a water quenching-bath, under an idler roller and finally on to a wind-up roller. The whole system is very nearly tensionless to prevent drawing of the film; nevertheless, the films produced do possess some orientation.

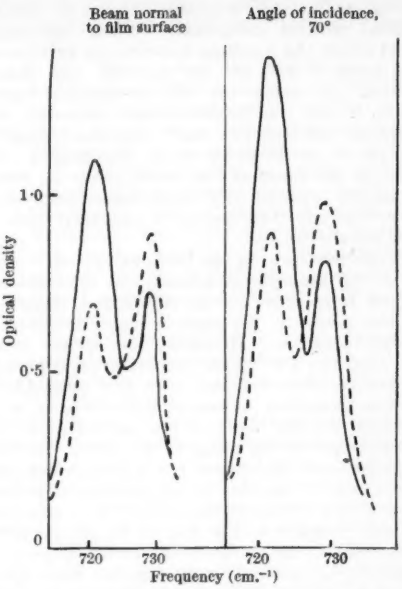
The samples available varied in thickness from 0·04 mm. to 0·11 mm. and proved to be of convenient thickness for all three experimental methods, and so no preparatory techniques which might have affected the molecular structure of the film were necessary.

The preferred orientation in the crystalline regions was deduced in the usual way from X-ray diffraction photographs of the film set up in various positions on the goniometer head. The indexing of the photographs and the subsequent interpretation of the results was carried out with the aid of the crystal structure proposed by Bunn[1]. It was found that the *a*-axes of the orthorhombic crystallites tend to lie parallel to the machine direction in the film (that is, the direction of travel of the film during production). The *b*- and *c*-axes are randomly oriented in a plane perpendicular to this direction.

Microscopic observation of the films in plane polarized light showed that all the films are optically biaxial and that the machine direction generally has the highest refractive index. Birefringence measurements on tilted specimens and on sections cut perpendicular to the machine direction and also observations of interference figures established the orientation of the optical indicatrix. With the usual nomenclature, γ lies along the machine direction, β is perpendicular to the machine direction in the plane of the film and α is perpendicular to both the machine direction and the plane of the film. $(\gamma - \beta)$ is about ten times as great as $(\beta - \alpha)$ and varies from -11 to $+41 \times 10^{-4}$ for the films examined.

Calculations of the principal refractive indices of the polythene molecule and crystal separately (from bond polarizabilities and the Lorenz–Lorentz equation)[2] showed that in both cases γ_{AC} is parallel to the chain axis; the suffixes A and C refer to the amorphous molecule and the crystal respectively. For the molecule, β_A is parallel to the plane of the carbon atoms but perpendicular to the chain axis, and α_A is perpendicular to both the plane of the carbon atoms and the chain axis. For the crystal, β_C lies along the *b*-axis and α_C along the *a*-axis. The optical evidence, together with the X-ray evidence that the chain (*c*-) axes of the crystallites are perpendicular to the machine direction, indicated that there must be considerable orientation of the amorphous molecules with the direction of their chain axes parallel to the machine direction.

Confirmatory evidence was obtained by the use of infra-red absorption measurements on the doublet band which occurs in the polythene spectrum at 721 and 729 cm.$^{-1}$. This has been ascribed by Sheppard and Sutherland[3] to a rocking motion of the methylene groups, and Elliott *et al.*[4] and Rugg *et al.*[5] have shown that in fully drawn polythene both parts of the band exhibit perpendicular dichroism. Therefore, we deduce that the transition moment causing this absorption is perpendicular to the carbon chain and parallel to a line joining the hydrogen atoms of a methylene group. The direction of this transition moment lies in the *ab* plane of the polythene crystal and makes an angle of 41° with the *a*-axis[1]. The component parallel to the *a*-axis is greater than that parallel to the *b*-axis and there is no component along the *c*-axis.



———, Electric vector perpendicular; – – – –, electric vector parallel to the machine direction

When polythene is melted, the peak at 729 cm.$^{-1}$ disappears and is therefore ascribed to the crystalline regions of polythene. The second peak, at 721 cm.$^{-1}$, although probably due in part to the crystalline material, is mainly due to the rocking vibration of the methylene groups in the amorphous regions. Consequently it is possible to obtain some measure of the orientation in crystalline and amorphous regions separately.

Observations were made using polarized infra-red radiation with the electric vector parallel and perpendicular to the machine direction. With the beam normal to the film, the 'amorphous' band at 721 cm.$^{-1}$ showed perpendicular dichroism (that is, there was greater absorption of the light with the electric vector vibrating perpendicular to the machine

Details of Results of X-Ray, Optical and Infra-red Examination of Polythene Films

Specimen No.	Thickness (mm.)	Birefringence $(\gamma - \beta)$	Dichroic ratio Amorphous	Dichroic ratio Crystalline	Order of orientation X-ray (cryst.)	Order of orientation Infra-red (cryst.)	Order of orientation Infra-red (amorph.)	Order of orientation Optical (cryst. + amorph.)
1	0·110	20·8	0·87	1·14	6	6	9	4
2	0·072	6·7	0·84	1·22	4	4	7	13
3	0·076	9·8	0·93	0·99	13	14	13	11
4	0·058	15·8	0·87	1·07	10	10	8	8
5	0·048	41·7	0·62	1·23	1	3	3	1
6	0·046	19·5	0·57	1·59	2	2	1	6
7	0·048	25·6	0·58	1·68	3	1	2	2
8	0·046	25·1	0·66	1·19	7	5	4	3
9	0·051	12·9	0·78	1·13	12	7	6	10
10	0·063	18·5	0·93	0·99	8	12	12	7
11	0·061	9·7	0·91	1·03	9	11	10	12
12	0·066	15·2	0·92	1·10	5	9	11	9
13	0·064	0	0·96	1·02	15	13	14	14
14	0·072	−11·1	0·78	1·12	11	8	5	15
15	0·064	19·8	0·96	0·96	14	15	15	5

direction); but the 'crystalline' band at 729 cm.$^{-1}$ exhibited parallel dichroism. When the film was rotated about the machine direction as axis to angles of incidence of 30°, 45°, 60° and 70°, the dichroism remained the same for the crystalline band at 729 cm.$^{-1}$, but the perpendicular dichroism of the absorption band at 721 cm.$^{-1}$ decreased slightly as the angle of incidence increased (see graph). These results on the band at 729 cm.$^{-1}$ indicated that the crystals are oriented with their *c*-axes perpendicular to the machine direction and probably with their *a*-axes parallel to it.

The observations on the band at 721 cm.$^{-1}$ showed that in the amorphous regions the orientation was different from that in the crystalline regions, and that the plane of the carbon chain contained the machine direction. However, the optical evidence shows that the axis of the carbon chain is parallel to the machine direction, and with this established the infra-red dichroism indicates that there is a slight preference for the plane of the carbon atoms to be perpendicular to the plane of the film. In view of this preference, the optical result that β was parallel to the plane of the film indicated a slight preference for the *c*-axes of the crystallites to lie in the plane of the film. Details of the results on fifteen different samples of film are shown in the accompanying table. It should be noticed that samples showing good amorphous orientation generally possess good crystalline orientation in a perpendicular direction.

A consideration of the manufacturing process helps towards an understanding of the formation of such an unusual structure. The extrusion through the slit followed by the downward flow into the quenching-bath produces good alignment of the polymer chains parallel to the machine direction, ready for crystallization to occur as soon as the film reaches the quench-bath. The water quenching-bath is often nearly boiling and therefore relaxation takes place simultaneously with crystallization. Nancarrow and Horsley[6] and also Brown[7] have found that, when relaxation of stretched polythene monofilaments occurs, the crystallites tend to take up a position with their *a*-axes parallel to the original direction of stretch. Our observations show that a similar orientation occurs in the relaxation of polythene film. Many attempts[8,6] have been made to explain the orientations occurring during the stretching and relaxing of polymers in terms of preferred cleavage and slip planes and also from a thermodynamic point of view, but none has been completely satisfactory. It is probable that the preferred directions of crystal growth are equally important in the present case where crystallization and relaxation are occurring simultaneously.

The amorphous regions of the film are formed of those polymer molecules which have an unfavourable spatial configuration for crystallization and necessarily show good orientation with their long axes in the machine direction. No explanation can be advanced at present for the slight amount of amorphous double orientation observed.

[1] Bunn, C. W., *Trans. Farad. Soc.*, **35**, 482 (1939).
[2] Bunn, C. W., and Daubeny, R. de P. (to be published).
[3] Sheppard, N., and Sutherland, G. B. B. M., *Nature*, **159**, 739 (1947).
[4] Elliott, A., Ambrose, E. J., and Temple, R. B., *J. Chem. Phys.*, **16**, 873 (1948).
[5] Rugg, F. M., *et al.*, *J. Poly. Sci.*, **9**, 579 (1952).
[6] Nancarrow, H. A., and Horsley, R. A., *Brit. J. App. Phys.*, **2**, 345 (1951).
[7] Brown, A., *J. App. Phys.*, **20**, 552 (1949).
[8] Bunn, C. W., and Garner, E. V., *Proc. Roy. Soc.*, A, **189**, 39 (1947).

CARBON DIOXIDE CONCENTRATION AND MAXIMUM QUANTUM YIELD IN PHOTOSYNTHESIS

By Prof. E. STEEMANN NIELSEN

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FOR fifteen years controversy has occurred about the maximum quantum yield in photosynthesis. Whereas one molecule of carbon dioxide is reduced by 3–4 quanta according to Otto Warburg and co-workers, at least 8 quanta are necessary according to Emerson and his school. Rabinowitch[1] has given a thorough review of the whole literature.

Warburg and co-workers[2,3] have, however, published the results of new experiments intended to explain why Emerson and his school have never been able to find a quantum yield higher than about 1/8. According to ref. 2, a carbon dioxide concentration of 5 per cent per volume is necessary both in an acid and in an alkaline medium in order to produce the maximum yield in *Chlorella pyrenoidosa*. Emerson's school used an alkaline medium (Warburg buffer No. 9), the carbon dioxide concentration of which is 0·2 per cent.

The optimum rate of photosynthesis at high light intensities in *Chlorella pyrenoidosa* is found both in an alkaline and in an acid medium already at very low concentrations of carbon dioxide (0·03 per cent according to Whittingham[4]). According to all reliable investigations[5], curves for different light intensities showing the dependence of the photosynthetic rate on carbon dioxide concentration at low concentrations merge into a single straight line. At low light intensities where the quantum yield is to be measured, saturation is achieved at lower concentrations rather than at high intensities.

The claim of Warburg that the optimum rate of photosynthesis at very low light intensities should need a concentration of carbon dioxide about two hundred times as high as the concentration necessary at high intensities thus seems erroneous. Experiments were therefore carried out with Warburg's strain of *Chlorella* in order to investigate the background of his statement. Both the rate of photosynthesis and the rate of respiration were measured by the Winkler method (oxygen metabolism). Fluorescent light was

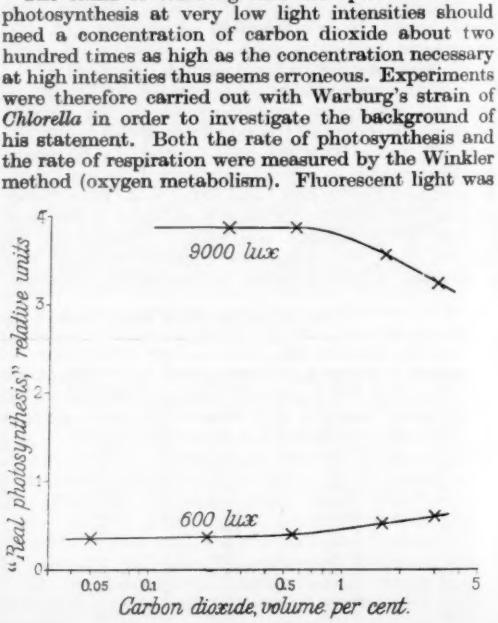

Fig. 1

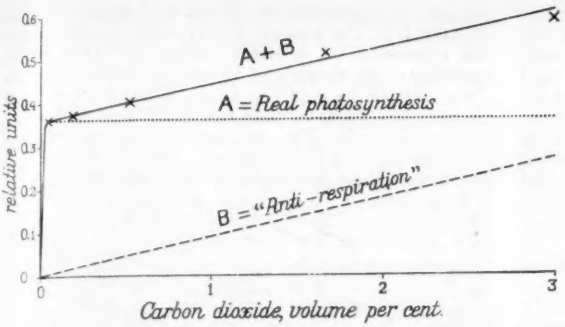

Fig. 2

employed. The maximum intensity was 9,000 lux. Lower intensities were obtained by using neutral filters. The experiments lasted 90–240 minutes.

The upper curve in Fig. 1 gives a typical example of a series of experiments at a high light intensity (*p*H 6·8, 21° C.). The different concentrations of carbon dioxide were made by mixing a solution of potassium bicarbonate with water saturated with carbon dioxide and water free of carbon dioxide. The concentration varied from 0·25 to 3·0 per cent. The lowest two concentrations were on the saturation plateau. Concentrations above 1 per cent, however, are too high for optimum photosynthesis. The rate at 3 per cent had decreased by 16 per cent.

In the lower curve in Fig. 2 the result of experiments made simultaneously at 600 lux is plotted. The shape of the curve differs definitely from the shape of the upper curve. From a concentration of about 0·3 per cent the curve unmistakably starts ascending. The rate of photosynthesis apparently increases by 50 per cent by increasing the carbon dioxide concentration from 0·5 to 3·0 per cent. This is nearly the same as shown by Warburg *et al.*[2].

The shape of the complete lower curve in Fig. 1, however, clearly indicates that this curve does not solely represent the dependence of photosynthesis on carbon dioxide concentration.

Kok[6] has shown that the light curve in photosynthesis undergoes a sudden change of slope somewhere near the compensation point. He presumes that dark respiration upon illumination is completely suppressed and substituted by another mechanism. A concentration of carbon dioxide of 5 per cent was employed. In later investigations[7] a concentration of only 0·2 per cent was employed. Although the temperature was increased to nearly 30° C. in order to bring about the break in the curve, only a slight break was found.

The only other investigator demonstrating the change of slope of the light curve in the neighbourhood of the compensation point is Van der Veen[8], who made his experiments with tobacco leaves in air with a carbon dioxide concentration of 3·6 per cent. In ordinary air (0·03 per cent carbon dioxide) a significant break has never been observed in leaves.

Variations of the carbon dioxide concentration have no influence on the rate of respiration of *Chlorella* in the dark. The rate was the same at 0·4, 1·2 and 5 per cent. The following survey is therefore presented concerning 'anti-respiration' in light, explaining at the same time the shape of the lower curve in Fig. 1.

(1) At low carbon dioxide concentrations light respiration corresponds to dark respiration.

(2) The part of the respiration located in the chloroplasts is apparently blocked up by high concentrations of carbon dioxide when at the same time a sufficient rate of photosynthesis is going on.

(3) Phosphates rich in energy produced during photosynthesis either reduce the respiratory intermediates back to the carbohydrate level or respiration is simply stopped due to the blocking up of the respiratory system. In Fig. 2 the lower curve shown in Fig. 1 is analysed according to this classification.

A third—possibly as likely—explanation is that normal photosynthesis is replaced by a photochemical reduction of intermediate respiration products (cf. Franck[9]).

Warburg *et al.*[10] have published experiments according to which the oxygen uptake by a *Chlorella* suspension in light was exactly the same as in the dark. They therefore rejected all hypotheses which postulate an interrelation between photosynthesis and respiration. As they, however, worked under conditions of complete absence of carbon dioxide, their argument does not concern the present theory.

Instead of computing the quantum yield from the slope of the light curves, Warburg and co-workers have confined themselves to measurements at a single light intensity. They first compensated for respiration by using white light, and then, by adding a definite amount of light energy, they measured the increase in rate of oxygen production or carbon dioxide uptake. Warburg *et al.*[2] mention that the absorbed light intensity must be small if a maximum yield is to be obtained. In fact, they used extraordinarily small light intensities. The intensity used for measuring quantum yield is normally at most about a third of the intensity necessary for reaching the compensation point. Linearity of light curves of *Chlorella*—apart from the break in Kok's curves—is found up to light intensities at least 3–4 times the intensity necessary for compensation of respiration.

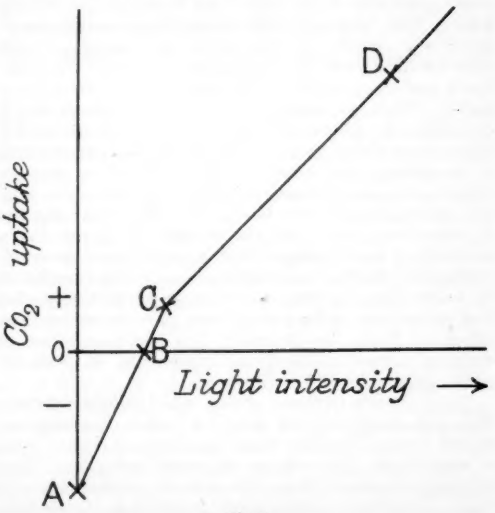

Fig. 3

In dense cell suspensions where light intensity varies considerably from cell to cell, 'anti-respiration' must be supposed to increase far above the compensation point. In Warburg's experiments a light absorption in the red part of the spectrum of about 2/3 was found. Fig. 3 gives a schematic light curve of *Chlorella* at a high concentration of carbon dioxide. *A C* is that part of the curve where 'anti-respiration' increases with increasing light intensity, *C D* is that part where 'anti-respiration' is constant and where the quantum yield is to be measured, *B C* that part where Warburg measured the quantum yield. It is not, therefore, surprising that this 'yield' is about double the size of the real one.

Efforts were made to measure 'anti-respiration' by using carbon-14. There are, however, too many complications if rate of photosynthesis and rate of respiration are to be measured separately by means of tracer carbon. The final report will appear in *Physiologia Plantarum*. [Jan. 7.

[1] Rabinowitch, E. J., "Photosynthesis and Related Processes", **2**, 1 (New York, 1951).
[2] Warburg, O., Geleick, H., and Briese, K., *Z. Naturforsch.*, **6b**, 285 (1951).
[3] Warburg, O., Geleick, H., and Briese, K., *Z. Naturforsch.*, **7b**, 141 (1952).
[4] Whittingham, C. P., *Nature*, **170**, 1017 (1952).
[5] Steemann Nielsen, E., *Physiol. Plantar.*, **5**, 145 (1952).
[6] Kok, B., *Enzymologia*, **13**, 1 (1948).
[7] Kok, B., *Biochim. et Biophys. Acta*, **3**, 625 (1949).
[8] Van der Veen, R., *Physiol. Plantar.*, **2**, 217 (1949).
[9] Franck, J., *Arch. Biochem.*, **23**, 297 (1949).
[10] Warburg, O., Burk, D., Schocken, V., Korzenovsky, M., and Hendricks, S., *Arch. Biochem.*, **23**, 330 (1949).

SYNOPTIC ROCKET OBSERVATIONS OF THE UPPER ATMOSPHERE

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ONE of the main limitations of present-day rocket research in the upper atmosphere is the fact that it is possible to make only a few launchings each year, generally from only one location (at White Sands, New Mexico)[1]. For many important investigations it would be desirable to conduct rocket observations more frequently, even though the payloads and the peak altitudes may not be particularly high. What is needed, then, is a method which combines the following features: (i) a cheap rocket (less than £300); (ii) an inexpensive and easy method of launching; (iii) the possibility of making launchings in any geographical location, for example, over the open sea and over the inaccessible polar regions or desert regions; (iv) the possibility of making a number of launchings within a short time interval, perhaps as short as a few minutes; (v) the possibility of controlling the time of firing to an accuracy of a few seconds in order to correlate it with occurrences observed from the ground; (vi) the possibility of making time-correlated measurements at two or more geographical locations.

An approach to these points, which might offer the first real possibility for synoptic rocket observations, would be provided by launching a small rocket from a high-flying (piloted or pilotless) aircraft. This suggestion arises from the pioneer experiments of Van Allen and collaborators[2], who have devised an inexpensive scheme for transporting some 20 kgm. (40 lb.) of apparatus to altitudes of about 80 km. (270,000 ft.). The essence of their scheme is to mount the apparatus on a small rocket, lift this entire assembly to an altitude of 15 km. (50,000 ft.; that is, above 90 per cent of the atmosphere) with a large polyethylene balloon, then fire the rocket in a near-vertical direction. The same rocket launched from sea-level reaches only about 20 km.; thus by eliminating the aerodynamic resistance of the lower atmosphere, a great increase in the peak altitude of the rocket can be realized. During the summer of 1952, several such launchings were successfully carried out near the geomagnetic pole under the leadership of Lieut. M. S. Jones, of the U.S. Office of Naval Research. The rockets employed were the very small, rapid-burning 'Deacon' rockets using a solid propellant of high specific impulse. The cost per rocket was about £300.

An important advantage of the aircraft-launching method suggested here lies in the elimination of inevitable and uncertain delays, which are inherent in balloon launchings and depend on surface wind conditions, plus the time it takes the balloon to reach altitude. In addition, the aircraft firing does away with the logistic difficulties and expense of transporting helium, balloon launching crew and equipment to the desired launching location. A further consideration is the fact that the actual location of firing, and therefore the probable impact area, can be controlled to much narrower limits than with balloons which are subject to wind conditions; this greatly simplifies the range-safety problem.

The uses to which such an inexpensive research rocket can be put are very wide and likely to be of importance in many investigations on the upper atmosphere. The region from 40 km. up to 80 km. (the position of the temperature minimum and generally taken to be the lower boundary of the ionospheric region) is an interesting one from the point of view of the structure of the atmosphere. Since the small rocket is not stabilized, and since it might not be worth while to install aspect-recording devices such as have been used for larger rockets, a different and perhaps simpler approach will have to be taken in some of the measurements. On the other hand, it would not be difficult to obtain a certain amount of gyroscopic stability by imparting a high angular velocity to a small flywheel with its axis mounted along the rocket axis; this might even be done from the launching plane by means of compressed air or electrically just before the actual firing. Measurements of ambient air pressures in the interesting region will be facilitated by the use of rockets of lower velocities. The technique of exploding grenades at high altitudes to obtain sound velocities, and thereby the temperature distribution[3], could, of course, be adapted easily for studying the latitude, diurnal and seasonal variations of upper air temperatures and winds. Studying the composition of the upper stratosphere would seem especially worth while in view of the recent discovery by Prof. F. A. Paneth's group that gravitational separation of light and heavy gases becomes appreciable at altitudes as low as 70 km.[4]. Air sampling bottles should be very appropriate for this investigation since the time spent between 70 km. and 80 km. is more than 90 sec., as compared with less than 15 sec. for the standard Aerobee rocket in current use. The accuracy to which the time of firing can be controlled, plus the easy accessibility of the rocket until just a few seconds before firing, make very feasible the scheme sug-

gested by Prof. F. E. Simon for collecting a much larger air sample by means of a liquid hydrogen condensation pump[5].

Prof. L. F. Bates has suggested the intriguing possibility of releasing material from a rocket so as to change the concentration of certain rare atmospheric constituents, such as sodium[6]. Even a small increase in the interval 70–80 km. might produce spectacular results in the light emission from the night sky. Again, the long time which the rocket spends in the interesting region may at last make this experiment possible.

Of particular meteorological importance would be regular synoptic measurements of the ozone content in the upper stratosphere using omnidirectional ozone detectors, such as photocells sensitive to the ultra-violet with suitable filters. Actual measurements of the vertical distribution of ozone would provide valuable calibrations of the zenith angle method used in sea-level observations[7]. Thus it would be possible not only to conduct simultaneous measurements at widely different locations of the ozone content and its distribution with altitude, but also to measure rapid changes in a particular location. The relation of such data to tropospheric weather[8] and to upper air temperatures would be of the greatest importance. Measurements in the highest layers of the ozonosphere in relation to solar phenomena would provide a valuable check of photochemical theory[9].

Essential to the understanding of photochemical and ionization reactions in the upper atmosphere[10] are periodical measurements of the solar ultra-violet radiation. They could be carried out without the necessity of sun-pointing and following devices, by using such wide-angle detectors as thermoluminescent crystals[11] or photon counters[12].

Another attractive opportunity for meteorological research arises from the possibility of synoptic high-altitude photography for the study of the distribution of clouds over a large area.

Several ionosphere investigations suggest themselves: for example, the measurement of high-altitude electric current systems in the auroral zone during different geomagnetic and auroral conditions by means of rocket-borne magnetometers[13], and radio propagation experiments to measure ion and electron densities. The low rocket velocity would simplify more direct methods for determining ion densities to check theoretical predictions[14] for this important quantity.

The altitudes reached by this rocket are of special usefulness for certain types of cosmic-ray experiments. For studying the position and extent of the low energy cut-off in the primary radiation[15], it would be desirable to make time-correlated measurements of the total intensity at various geomagnetic latitudes. Another important investigation concerns fluctuations, correlated with solar phenomena, of the extremely soft component of the primary radiation which may enter at very high latitudes, but which is unable to penetrate more than about 1 gm./cm.^{2} thickness of matter. This soft radiation is thought to be the most sensitive indicator of solar effects of cosmic rays. The short time which the rocket spends above the appreciable atmosphere (above 50 km. for cosmic-ray purposes) constitutes no particular handicap, for omnidirectional detectors giving high counting-rates can be used; a statistical accuracy of one per cent is easily obtainable.

It is clear that the list of possible investigations given above is incomplete. Once this technique of upper air exploration has been put in operation, many other, and possibly more important, investigations will undoubtedly suggest themselves to specialists in various fields.

Compared to ground-launched large rockets, the method suggested here would not only be within the scope of a much more modest research budget, but also would actually make possible studies of physical problems of the atmosphere and studies of extra-terrestrial radiation which are outside the range of, but complementary to, present-day high-altitude rocket experiments. It would, in fact, put rocket research on much the same basis as weather balloon soundings or ionosphere radio soundings.

The opinions or assertions in this article are the private ones of the writer, and are not to be construed as official, or reflecting the views of the United States Navy. [March 23.

[1] Singer, S. F., *Nature*, **171**, 146 (1953).
[2] Van Allen, J. A., and Gottlieb, M. B. (to be published).
[3] Ference, M., *J. Meteorol.* (to be published).
[4] Chackett, K. F., Paneth, F. A., Reasbeck, P., and Wiborg, B. S., *Nature*, **168**, 358 (1951).
[5] Simon, F. E., *Nature*, **164**, 179 (1949).
[6] Bates, D. R., *J. Geophys. Res.*, **55**, 347 (1950).
[7] Götz, F. W. P., Meetham, A. R., and Dobson, G. M. B., *Proc. Roy. Soc.*, A, **145**, 416 (1934).
[8] Dobson, G. M. B., Brewer, A. W., and Cwilong, B. M., *Proc. Roy. Soc.*, A, **185**, 144 (1946).
[9] Chapman, S., *Mem. Roy. Met. Soc.*, **3**, 103 (1930); *Proc. Roy. Soc.*, A, **132**, 353 (1931).
[10] Mitra, S. K., "The Upper Atmosphere", 2nd ed. (Calcutta, 1952).
[11] Tousey, R., Watanabe, K., and Purcell, J. D., *Phys. Rev.*, **83**, 792 (1951).
[12] Friedman, H., Lichtman, S. W., and Byram, E. T., *Phys. Rev.*, **83**, 1025 (1951).
[13] Singer, S. F., Maple, E., and Bowen, W. A., *J. Geophys. Res.*, **56**, 265 (1951); *Nature*, **170**, 1093 (1952).
[14] Bates, D. R., and Massey, H. S. W., *J. Atm. Terr. Phys.*, **2**, 1 (1951).
[15] Van Allen, J. A., and Singer, S. F., *Nature*, **170**, 62 (1952).

GREGARIOUSNESS IN BARNACLES IN RELATION TO THE FOULING OF SHIPS AND TO ANTI-FOULING RESEARCH

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BECAUSE of their relevance to applied work, we feel it is desirable to direct attention to the results of investigations at this station on the setting behaviour of three species of barnacles, *Balanus balanoides*, *Balanus crenatus* and *Elminius modestus*, as observed in the laboratory. The last two species are important fouling organisms, and it seems likely that the phenomena described below will also be found in other species not yet investigated. Gregarious settlement in *Elminius modestus* has previously been reported as a result of field experiments[1].

Setting is encouraged by gentle water movement which stimulates attachment. After alighting on a suitable surface, the cyprids walk about, pulling themselves forward by each antennule alternately, and changing direction only infrequently. They swim off again much more readily than has hitherto been assumed, and on an unsuitable surface such as glass, or one with loose particles, or at a sharp edge, they may swim off almost at once. If, however, they

encounter a barnacle of their own species or even the persistent basis of such an individual, they then rarely swim off, but instead embark on a characteristic setting-action pattern. During this stage, which has been observed by Doochin[2], a cyprid walks more slowly with random changes in direction of increasing frequency, pivoting on one antennule and testing the substratum with the other. After spending about half an hour in the reconnaissance of a small area, stopping and turning in one small depression after another, it normally comes to rest in one of them. Here it moves to and fro, rotates and flicks the posterior cirri vigorously to sweep out any silt or loose particles. It then pulls itself down on its antennules in a direction facing the incident light, or as nearly as is compatible with its fitting snugly into the depression. Contrary to previous belief[3], this final orientation is achieved by a distinct reaction at the time of setting. Slight rolling movements, due to alternate pulling on the antennules, then ensue, and the attachment cement is ejected and spread around the antennulary suckers. Finally, all movements cease until metamorphosis is heralded by renewed activity about twenty hours later in *Balanus balanoides* and *B. crenatus*, and about four hours later in *Elminius modestus*. It is interesting to note that the setting behaviour pattern of barnacles, with a wide initial exploration and a detailed final search after encountering its own species, is remarkably similar to that of oysters[4] and *Spirorbis*[5], providing a good example of convergent evolution.

We have also noted that if cyprids make contact with attached individuals on a surface intrinsically unfavourable for setting (for example, glass, or one crowded with recently settled barnacles) they may swim off again but are then more ready to begin colonizing bare surfaces. This explains the especially rapid fouling of surfaces in the vicinity of shores where adults are abundant[1] and the rather slow initial colonization of new sea-walls[6] and ships newly painted with non-toxic paint. Such craft moored alongside quays heavily barnacled by the appropriate species will tend to be fouled more readily than they would be if moored away from such places, even though cyprids be equally abundant. Moreover, once a ship has been fouled, cleaning by mere scrubbing down will leave behind the bases, and these will stimulate rapid re-colonization.

The property of the cemented bases which stimulates setting is removed only by such powerful reagents as attack quinone-tanned proteins; sodium hypochlorite, for example, dissolves the bases away. Tests carried out on cyprids show that the surface gives a strong argentaffine reaction, local chromaffine staining and a positive response to the diazo and indophenol tests, indicating the presence of a phenolic substrate. These observations afford evidence that the epicuticle of barnacles, like that of other arthropods[7], contains a quinone-tanned protein. The thin epicuticle and the attachment cement have been shown by Thomas[8] to be of the same material and secreted by similar tegumental glands. It is probably this substance which is detected in some way by the crawling cyprid. To remove the bases by chemical means from the bottom of a ship is scarcely practicable, nor is it necessary, for if the bases are covered with new paint, or even by a continuous film of nitrocellulose, they will no longer induce setting.

When testing anti-fouling paints, differences between toxic panels and non-toxic controls are sometimes masked by abnormal variations in numbers of barnacles setting on replicates. This may render any valid comparison difficult, and in any event reduces the precision of the experiment. Such differences now appear to be due, not so much to variation in the numbers of larvæ available for attachment, but rather to the hitherto unsuspected fact that the presence of settled individuals induces others to settle. Hence the rate of settlement will not be uniform, even when the number of cyprids arriving from the plankton is constant. If, for example, each cyprid explores an area A, and settles only if it meets a previously settled individual, the rate of increase, dn/dt, in the number per unit area, n, assumed randomly distributed over the surface, will be $dn/dt = N(1 - \exp - An)$, where N is the number arriving on unit area in unit time. Thus colonization of a bare panel will show an initial time-lag prior to the setting of a pioneer individual, then a logarithmically increasing rate of settlement (while $An \ll 1$), then a steady rate (when $An \gg 1$) equal to N, and finally a decreased rate since a crowded surface is repellent. Small time-differences in gaining an initial settlement, since they are followed by a logarithmic increase, will result in wide divergences in numbers on replicate panels, until crowding, by reducing settlement on the more densely populated surfaces, leads to greater uniformity. Results conforming to this sequence have been repeatedly obtained in practice.

It also follows from these observations that a test panel which has gradually lost its toxicity might remain clean for some time if settlement is light, but when the first pioneers become attached, further settlement might take place so rapidly as to suggest sudden loss of toxicity. On the other hand, cyprids persistently attempt to settle on test panels adjoining dense populations of adults. If the paint is not quite lethal, metamorphosis may take place, but the spat readily fall off, presumably because the paint is still able to upset the cementing mechanism. Those that first succeed in cementing themselves permanently may afterwards show deficient basal growth or distorted bases, as previously noted by Weiss[9].

On the basis of these findings, we suggest the following refinements in the testing of anti-fouling paints for effectiveness against barnacles.

(*a*) The test raft should be kept well covered with barnacles.

(*b*) The test surface should, if possible, be contiguous with a heavily barnacled surface.

(*c*) Control panels of two kinds should be employed: (i) quite bare, with a surface similar to the paint surface but non-toxic, to indicate the 'pioneer' attack; (ii) covered with bases of locally abundant species to give the maximum settlement.

(*d*) In comparing the number setting on test panels and non-toxic controls, due allowance should be made for the influence of previously settled individuals on the rate of settlement.

[1] Knight-Jones, E. W., and Stevenson, J. P., *J. Mar. Biol. Assoc.*, **29**, 281 (1950).
[2] Doochin, H. D., *Bull. Mar. Sci. Gulf and Carib.*, **1**, 15 (1951).
[3] Barnes, H., Crisp, D. J., and Powell, H. T., *J. Anim. Ecol.*, **20**, 227 (1951).
[4] Nelson, T. C., *Biol. Bull. Woods Hole*, **46**, 143 (1924). Prytherch, H. F., *Ecol. Monogr.*, **4**, 49 (1934). Cole, H. A., and Knight-Jones, E. W., *J. Cons. Int. Explor. Mer*, **14**, 86 (1939).
[5] Knight-Jones, E. W., *J. Mar. Biol. Assoc.*, **30**, 201 (1951).
[6] Moore, H. B., *J. Anim. Ecol.*, **8**, 29 (1939).
[7] Prior, M. G. M., *Proc. Roy. Soc.*, B, **128**, 378, 393 (1940). Dennel, R., *Proc. Roy. Soc.*, B, **134**, 79 (1947).
[8] Thomas, H. J., *Quart. J. Micro. Sci.*, **84**, 257 (1944).
[9] Weiss, C. M., *Ecology*, **29**, 116 (1948).

LETTERS TO THE EDITORS

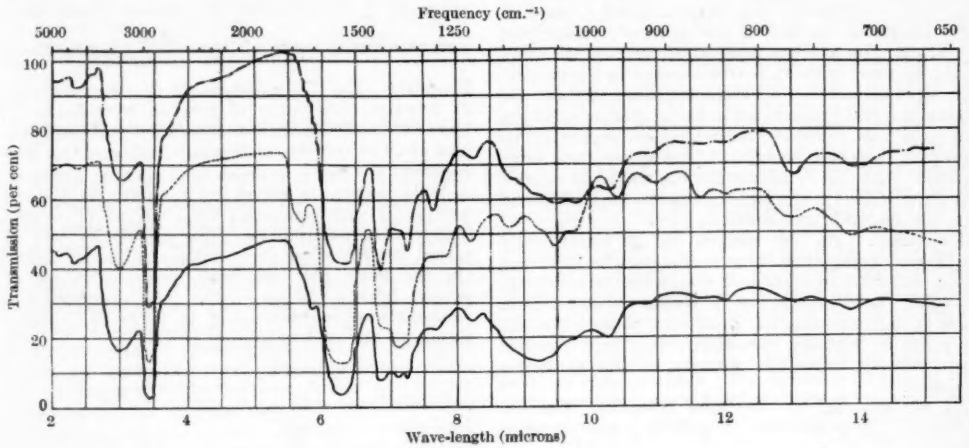
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Fluoroacetate Poisoning: Comparison of Synthetic Fluorocitric Acid with the enzymically synthesized Fluorotricarboxylic Acid

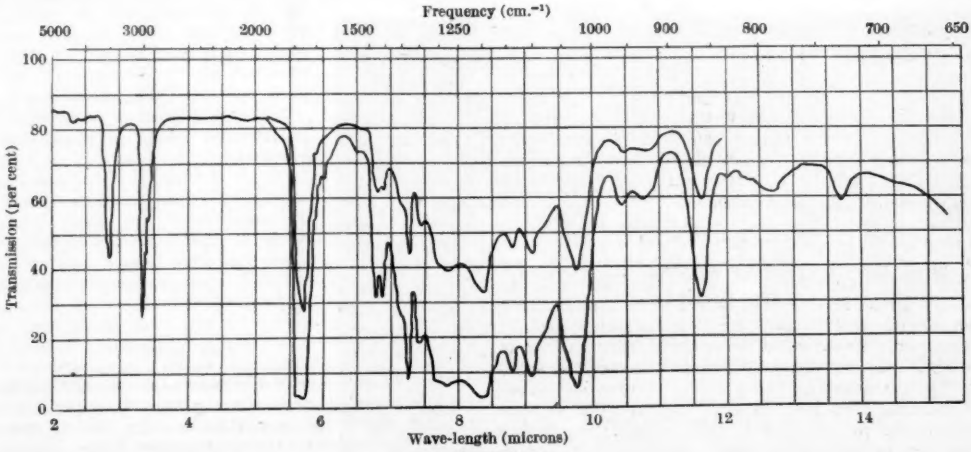
THE hypothesis advanced earlier to account for the toxicity of fluoroacetate ($FCH_2.COONa$) has been proved recently by the isolation of an enzymically synthesized mono-fluorotricarboxylic acid in crystalline form[1], prepared from the products of interaction of kidney tissue with fumarate and fluoroacetate. Though there was much to suggest that it was mono-fluoro*citric* acid, this had not been rigorously proved by a comparison of the infra-red spectrum with a synthetic specimen. The recent synthesis by one of us (D. E. A. R., in the press) of fluorocitric acid has made it possible to compare the infra-red spectra of the barium salts of this with the barium salt from 1·5 mgm. of the enzymically synthesized (natural) crystalline compound isolated in Oxford (by R. A. P. and R. W. W.).

Infra-red spectra. The curves obtained from the barium salts are shown in the accompanying spectra; this salt was used as it proved to be the most convenient compound for infra-red study. Though the spectrum of the product of biochemical synthesis differs slightly from the spectrum of barium fluorocitrate, the differences are such as would be caused by the presence of small amounts of barium citrate and barium sulphate as impurities; in the purest specimen (–·–), the citrate present is thought not to be greater than 5 per cent, which explains why it was not detected by the colorimeter tests[1].

These spectra were obtained from 'Nujol' mulls of the barium salts, using a micro technique. The spectrometer used was a double-beam Perkin–Elmer, Model 21.



Spectra 1



Spectra 2

Spectra 1. Comparison of infra-red spectra of barium salt of synthetic fluorocitrate (dotted curve) with the spectra of barium salts of fluorotricarboxylic acid enzymically synthesized from fluoroacetate; ———, first sample showing the band at 9·75 microns; _·_·_·_, highly purified crystalline specimen

Spectra 2. Ethyl fluorocitrate

The spectrum of the sample of ethyl fluorocitrate, from which the barium fluorocitrate was prepared, is also reproduced for reference.

Activity as inhibitor of citric acid metabolism. Using the usual test, Peters *et al.*[1] found that 0·61 μgm. of the 'natural' fluorocitrate inhibited the disappearance of 1 μmole citric acid under the conditions of the test made with particle preparations from kidney.

During the course of the work at Porton (by D. E. A. R.), several specimens of synthetic fluorocitric acid have been examined in Oxford, which have not shown more than half the biochemical activity of the 'natural'. The barium salt from the purest synthesized specimen was dissolved in hydrochloric acid and the barium precipitated with sodium sulphate. After removal of barium sulphate, an activity test showed the following for μmoles inhibited: 10 μgm. barium salt inhibited 4·86 μmol. citric acid, from which it can be calculated that 1 unit of inhibitor is equivalent to 1·04 μgm. synthetic fluorocitric acid. Another test gave 1·07 μgm.

Allowing for experimental error, an average of 1·05 μgm. (synthetic) has approximately one-half the biochemical activity of the 'natural', determined as 0·61 μgm. on average (0·58–0·64, ref. 1). As there should be two optically active centres in fluorocitric acid, there should be four stereoisomers; if these are present in equal proportions in the synthetic mixture, then only one optically active centre seems to be important for the activity. Elsewhere, we have reported[2] that the synthetic fluorocitrate has similar convulsive effects in the pigeon brain to those obtained with the enzymic preparation.

Conclusion. As the spectra of the enzymically synthesized compound show no bands which cannot be accounted for by the bands seen with the synthetic fluorocitric acid together with bands expected from traces of barium salts, the compound made enzymically must be actually monofluoro*citric* acid; it has approximately twice the activity of the synthetic specimen.

We are grateful to the Chief Scientist, Ministry of Supply, for permission to publish some of these results.

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[1] Peters, R. A., Wakelin, R. W., Buffa, P., and Thomas, L. C., *Proc. Roy. Soc.*, B, **140**, 497 (1953).
[2] Peters, R. A., *Brit. Med. J.*, ii, 1165 (1952). Peters, R. A., and Wakelin, R. W., *J. Physiol.* (in the press).

A New Application of EDSAC to Crystal Structure Analysis

It is well known that the structure of a centrosymmetric crystal could be solved by selecting a number N of structure factors ($F(\mathbf{h})$'s), and evaluating the electron density

$$\rho(\mathbf{r}) = \frac{1}{V} \sum_{\mathbf{h}} \pm |F(\mathbf{h})| \cos 2\pi \mathbf{h}.\mathbf{r}$$

for each of the 2^N possible sign combinations on the $F(\mathbf{h})$'s. The correct choice of signs would give a recognizably correct structure when N was sufficiently large. For crystals of moderate complexity, experience has shown that the structure can be determined after the correct signs of about twenty of the largest structure factors have been found. Even when a very rapid means of evaluating a multi-dimensional Fourier series, such as Pepinsky's X.R.A.C.[1], is available, it is not feasible to evaluate and inspect about 2^{20} (more than a million) electron-density maps. Our application of the EDSAC consists effectively in making the machine survey this large number of alternative answers, and select from them a few which fulfil certain criteria. The following is a brief outline of the method.

Not all sign combinations are *a priori* equally probable; but inequality relations between structure factors, for example, generally rule out only a small proportion of them—in the example which we give later, they impose no immediate limitations. On the basis of results obtained by Sayre[2], it may be shown that the extent to which $\chi \equiv \sum_{\mathbf{h}} \sum_{\mathbf{h}'} U(\mathbf{h})U(\mathbf{h}')U(\mathbf{h}+\mathbf{h}')$ is positive may be taken as a measure of the 'plausibility' of a particular set of signs, as a positive value of χ corresponds to positive peaks in the electron-density map. ($U(\mathbf{h}) = \frac{F(\mathbf{h})}{F(0)f}$, see Harker and Kasper[3].) The U's involved in this summation are in practice only those of greatest magnitude. We have used salicylic acid[4] as an example. As an approximation, the differences in magnitudes of the largest eighteen U's were ignored, and then χ, apart from a scale factor, is given by making all the $|U|$'s unity. χ was evaluated for each of $2^{16} = 65{,}536$ independent possibilities. This calculation was completed in less than three hours using the EDSAC. On the scale that we used, possible values of χ ranged from + 29 to − 29. The number of sign combinations corresponding to each value of χ is shown in the accompanying table.

Value of χ	No. of sign combinations
29	0
27	0
25	0
23	0
21	6
19	27
17	79
15	250
13	632
11	1,320
9	2,404
7	3,975
5	6,043
3	8,076
1	9,386
− 1	9,644
− 3	8,588
− 5	6,536
− 7	4,356
− 9	2,472
− 11	1,111
− 13	426
− 15	159
− 17	42
− 19	4
− 21	0
− 23	0
− 25	0
− 27	0
− 29	0
Total	65,536

The correct sign combination (known in this case since the structure is already known) is not one of the six giving the largest value of χ, but is one of twenty-seven giving the next largest value. It would be quite feasible to investigate the ρ-distribution corresponding to each of about thirty sign combinations, but in fact in this case other criteria could be used for limiting the search still further.

We have also developed a method, which again makes use of the EDSAC, by which those sign combinations which give acceptably large values of χ can be singled out in a few minutes of machine time. We believe that in this way it will be possible to determine rapidly the structures of crystals of about the same complexity as the example we have mentioned. The method we have outlined would be particularly valuable when used in conjunction with X.R.A.C., which would provide a rapid means of testing the most plausible sign combinations.

A full account of this work will be published elsewhere.

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[1] Pepinsky, R., *J. App. Phys.*, **18**, 601 (1947).
[2] Sayre, D., *Acta Cryst.*, **5**, 60 (1952).
[3] Harker, D., and Kasper, J. S., *Acta Cryst.*, **1**, 70 (1948).
[4] Cochran, W., *Acta Cryst.*, **6**, 260 (1953).

Cytoplasmic Particles in Bean Root Cells

IN a recent report, E. Robinson and R. Brown[1] have described particles obtained by aqueous extraction from bean root cells which are similar to the isolated microsomes described by Claude[2], Brachet and Jeener[3] and Chantrenne[4]. The particles observed by the latter workers in extracts from many different animal tissues and from yeasts were found to contain ribose nucleic acid, whereas the results of Robinson and Brown suggest that the particles obtained by them may not contain ribose nucleic acid. Preliminary observations made by us on particles isolated from bean root cells by differential centrifugation indicate that particles containing ribose nucleic acid are obtainable from this material, and that the content of this substance varies with the size of the particle in the same way as with the particles isolated by Chantrenne[4] from mouse liver. The presence of the particles in the root-tip cells has also been demonstrated by an electron microscope study of thin sections of the root tips and of the isolated particles.

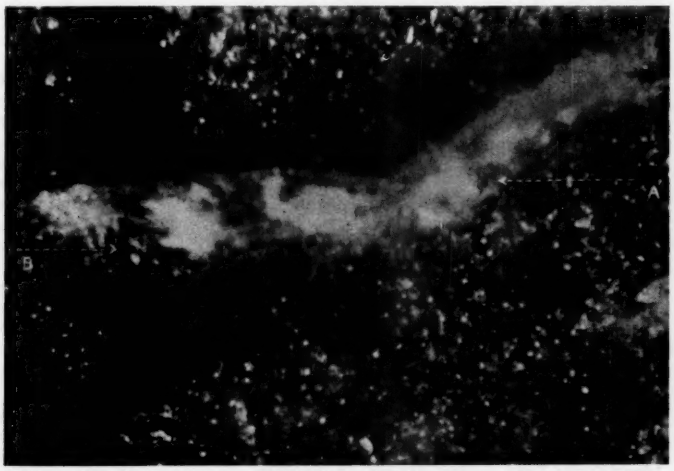
Roots were obtained by germinating seeds of broad bean on filter paper saturated with water at 20° C. The lateral root tips were harvested after seven days, care being taken not to include that part of the root distal from the tip where secondary thickening occurs, and the particles were isolated as follows:

The root tips were suspended in 15 volumes of *M*/150 phosphate buffer, *p*H 7·2, at + 4° C., broken up by a brief treatment with a blendor at low speed, and homogenized in a Potter homogenizer. Debris was then removed by two centrifugations at 1,400 *g* for 10 min. at 0° C. The centrifugate, which contained a negligible amount of intact cellular material, was discarded. The opalescent supernatant was then centrifuged for one hour at 1,400 *g*, at 0° C., giving a centrifugate, *A*, which was resuspended in the buffer and washed by centrifugation at the same speed. Centrifugate *B* was obtained by centrifuging the supernatant from *A* at 25,000 *g* for 1 hr. at 0° C., and was washed in the same way. Fraction *C* was isolated from the supernatant of *B* by centrifuging for 2 hr. at 130,000 *g* in a Phywe ultracentrifuge at a mean temperature of 23·5° C.

Fraction	Centrifuging conditions	mgm. RNA/mgm. N
A	1,400 *g* for 1 hr.	0·5
B	25,000 *g* for 1 hr.	0·81
C	130,000 *g* for 2 hr.	1·01

The centrifugates *A*, *B* and *C* were dispersed in small quantities of distilled water, and determinations of the nitrogen content per millilitre were made by a micro-Kjeldahl method. The ribose nucleic acid content of the suspended granules was estimated by the method of Ogur and Rosen[5]. Measured samples of the suspension were shaken with an equal volume of 5 per cent perchloric acid for 8 hr. at room temperature. The extracted ribonucleotides were estimated in a Hilger spectrophotometer by their absorption at 260 mμ, using a highly purified yeast ribose nucleic acid as a standard. The variation of the ribose nucleic acid content of the fractions with the condition of centrifugation is shown in the accompanying table. From this table it can be seen that the ribose nucleic acid content of the granules increases as the size of the granule decreases, as found in the case of animal material[4]. The magnitude of the ribose nucleic acid content and its variation with centrifuging conditions is of the same order as that observed previously[4] for liver microsomes.

The occurrence of the small particles inside the cells was also studied. The apical 4–5 mm. of roots of the same variety of beans were fixed in a bichromate and osmium fixative (Newcomer–Zirkle procedure[6]) and embedded in ester wax. The roots were cut longitudinally into sections of about 0·1 μ thickness



Thin section of a bean root. Magnification × 20,500. The cytoplasm is filled with small granules. Two larger cytoplasmic organelles (*A* and *B*) which would be resolved by ordinary light microscopy can also be seen. The structure of particle *B* appears slightly analogous with that of animal mitochondria (ref. 7)

on a microtome, the design of which was begun in this laboratory by S. G. Tomlin and developed and completed by S. Fitton Jackson and W. E. Seeds (unpublished). The sections were examined in a Metropolitan-Vickers *EM3* electron microscope at 75 kV. and a magnification of × 8,200. The cell walls showed middle lamellæ and did not appear to be distorted; they also contained dense bodies which were round in section. No precipitation effects were observed in the cytoplasm, which contained many particles of various sizes and types. The smallest particles observed were small dense bodies, the size of which was estimated very roughly as about 400 A. in diameter (see photograph). The particles which were sedimented at 130,000 *g* were also examined in the electron microscope, and were apparently identical with the minute cytoplasmic particles observed in thin sections.

The choice of the fixative was decided by the fact that it had yielded good structural preservation of the cytoplasmic organization of these cells, so far as could be ascertained with the light microscope. Improved methods of fixation are being developed, however, since this fixative gives variable results.

In our opinion, therefore, bean root tip cells contain cytoplasmic particles which, as regards their ribose nucleic acid content, are completely analogous to the particles studied by previous workers in animal tissues and in yeast. The particles described by Robinson and Brown very probably contain ribose nucleic acid also; a possibility which they took care not to exclude in their communication. We have recently learned from Dr. Robinson (private communication) that she too has now fractionated these particles in an ultracentrifuge and has obtained from them an absorption curve resembling that of nucleic acid.

We wish to thank Prof. J. T. Randall and Dr. M. H. F. Wilkins for encouragement in this work, and Dr. E. Robinson for helpful discussion. We also wish to thank Miss F. Ticehurst for help with the photography. One of us (J. C.) acknowledges a grant from the British Empire Cancer Campaign which enabled him to participate in this study. We are also grateful to the Rockefeller Foundation for the purchase of equipment used in this investigation.

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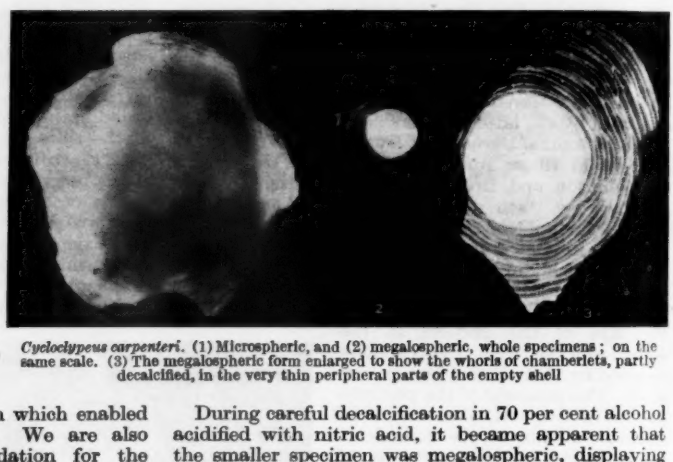
[1] Robinson, E., and Brown, R., *Nature*, **171**, 313 (1953).
[2] Claude, A., *Science*, **97**, 451 (1943).
[3] Brachet, J., and Jeener, R., *Enzymologia*, **11**, 196 (1945).
[4] Chantrenne, H., *Biochim. et Biophys. Acta*, **1**, 437 (1947).
[5] Ogur, M., and Rosen, G., *Arch. Biochem.*, **25**, 262 (1950).
[6] Zirkle, C., *Bot. Gaz.*, **88**, 186 (1929). Chayen, J., and Miles, U. J. (in preparation).
[7] Pallade, G. E., *Anat. Rec.*, **114**, 427 (1952).

Nuclei of *Cycloclypeus carpenteri* Brady

This beautiful large nummulite is collected now and then in the living state in the East Indian seas; but the major interest of the collectors always seems to be in the shell. We have, so far as I am aware, no description of the living animal, nor even of its pseudopodia; and nothing since the time of Lister[1] about its protoplasmic structures.

Lister gives a succinct account of what was then known of *Cycloclypeus*, with illustrations (ref. 2, pp. 130–132), and discusses the morphology of the shell with regard to its probable course of development. The initial chambers of both the megalospheric and the rare microspheric forms are described; and, in the case of the former, "a single large nucleus was found in one of the large central chambers" as figured in Lister (ref. 1).

Quite recently, by the good offices of Mr. Cameron D. Ovey of the British Museum (Natural History), London, there came into my possession two specimens preserved in neutral formalin, and sent by Miss Ruth Todd of the U.S. National Museum, New York. They are from a collection labelled U.S. 6184, "Outer slope, Bikini Atoll, Marshall Is.". The smaller specimen measured 11 mm. in its greatest diameter, and the larger one 25 mm. They are illustrated herewith.



Cycloclypeus carpenteri. (1) Microspheric, and (2) megalospheric, whole specimens; on the same scale. (3) The megalospheric form enlarged to show the whorls of chamberlets, partly decalcified, in the very thin peripheral parts of the empty shell

During careful decalcification in 70 per cent alcohol acidified with nitric acid, it became apparent that the smaller specimen was megalospheric, displaying the typical central shell structure shown by Lister (ref. 2, p. 131). Traces of the septal canals were seen in the organic shell matrix between the chamberlets, but no protoplasm remained in the shell. The canals contain, here and there, collections of the brown xanthosomes (? excretory granules), which are also present in patches elsewhere on the animal. The larger specimen, on the other hand, showed no indication of the robust central structure of this phase, and although its centre was not clear, it was certainly microspheric. The shell contained protoplasm, and pieces of the large fragile disk-like animal were stained in borax carmine and mounted in balsam on slides. In about a dozen of the middle whorls of chamberlets there appeared a large number (several hundreds in all) of rounded nuclei, some 15–20 μ in diameter, one to three in a chamberlet. No intranuclear structure could be made out. The 'heterostegine' type of protoplasmic intercommunica-

tion between the chamberlets is clearly seen, that is, connexions with adjacent chamberlets on either side in preceding and succeeding whorls, but none with neighbours of the same whorl; and the canal system full of protoplasm is also visible in the thick septa of the shell.

This note is published only partly in order to record the expected multinuclear nature of a microspheric *Cycloclypeus*. Our too fragmentary knowledge of this surviving protozoan prehistoric monster will no doubt some day be amplified, and a great part of the object in writing this letter lies in the hope that it may help to speed that day.

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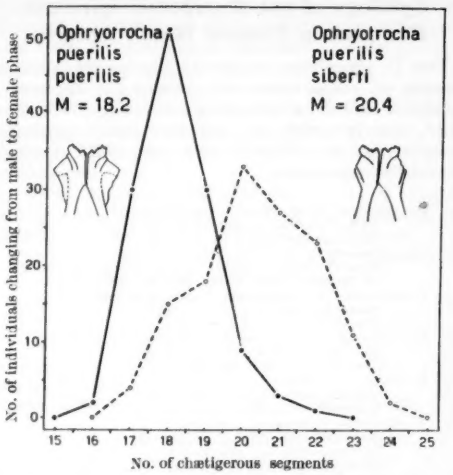
[1] Lister, J. J., *Phil. Trans.*, B, **186**, 437 (1895).
[2] Lister, J. J., "Foraminifera", in "A Treatise on Zoology", edit. by E. Ray Lankester, Pt. 1, 2 (London).

Genetic and Morphological Evidence for Subspecific Differences between Naples and Plymouth Populations of *Ophryotrocha puerilis*

INDIVIDUALS of *Ophryotrocha* until now classified as *O. puerilis* and collected in the Bay of Naples and at Plymouth breed normally, if kept in Naples water, under conditions described elsewhere[1]. The Naples and the Plymouth populations are unquestionably closely related and have the same chromosome number ($2n = 8$). However, cross-breeding between a Naples individual and a Plymouth individual has constantly resulted in embryos which degenerated at an early stage and were eaten by their parents.

O. puerilis is known as a protandrous hermaphrodite[2]. Comparative studies of the first appearance and development of eggs in numerous individuals kept under identical conditions at a temperature between 17° and 18° C. gave the following results: (*a*) Small oocytes first appear in isolated Naples individuals at a mean size of eighteen chætigerous segments, whereas in isolated Plymouth individuals they appear at a mean size of twenty chætigerous segments (see graph). (*b*) The complete maturation of oocytes takes place in all the isolated Naples individuals, while the maturation of oocytes is seldom reached in isolated Plymouth individuals. (*c*) The Plymouth individuals in the female phase appear to reverse into the male phase more rapidly than the Naples individuals under the action of environmental factors[3]. This result may be partially explained by observations (*a*) and (*b*).

A careful morphological examination of the Naples and Plymouth specimens—both alive and preserved—revealed to one of us no substantial differences other than in the two parts of the mandibles (nomenclature from McIntosh[4]). The crenate apical portion of each of these pieces is supported by a plate which is comparatively large in the Plymouth individuals, but is much reduced or even absent in the Naples individuals. The wing-like border occurring close behind the anterior region is also rather elongated in the Plymouth strains, more triangular and broader in the Naples strains (see graph).



Ophryotrocha puerilis puerilis (continuous line) and *O. puerilis siberti* (broken line). Left: mandibles of *O. puerilis puerilis*; right: mandibles of *O. puerilis siberti*

In a survey of the available literature on the Mediterranean and Atlantic *Ophryotrocha*, no detailed observations have been found on the structure of the mandibles; but some information has been collected by the examination of some carefully drawn outlines of the armature of the proboscis. It appears, for example, that the *Ophryotrocha* from Whitstable oyster beds described by McIntosh[5] under the name *Staurocephalus siberti* almost certainly corresponds to the Plymouth *Ophryotrocha* now being cultivated in the Naples Zoological Station.

From a strictly genetic point of view, the *Ophryotrocha* from Plymouth now studied should be named as a separate species from the Naples *Ophryotrocha* which is the true *puerilis*, since Claparède and Mecznikow[6] collected their specimens in the Bay of Naples. However, a number of considerations, which will be discussed elsewhere, induce us to adopt the trinomial nomenclature (*Ophryotrocha puerilis puerilis* Clap. and Meczn. from the Bay of Naples, and *O. puerilis siberti* McInt. from Whitstable and Plymouth) in order to stress the close relationship between the two populations.

A more detailed paper on this subject will be submitted elsewhere.

Our thanks are due to Mr. F. S. Russell, and to the staff of the Marine Biological Laboratory, Plymouth, for the many courtesies extended to us.

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[1] Bacci, G., *Exper.*, **7**, 222 (1951); *Boll. Soc. Ital. Biol. Sper.*, **27**, 778 (1951).
[2] Braem, F., *Z. wiss. Zool.*, **57**, 187 (1893). Korschelt, E., *Z. wiss. Zool.*, **57**, 224 (1893).
[3] Bacci, G., *Boll. Soc. Ital. Biol. Sper.*, **28**, 1296 (1952).
[4] McIntosh, W. C., "British Marine Annelids", **2**, 364 (1908).
[5] McIntosh, W. C., *Ann. Mag. Nat. Hist.*, (5), **16**, 480 (1885).
[6] Claparède, E., and Mecznikow, E., *Z. wiss. Zool.*, **19**, 163 (1869).

Cytology of the *Dryopteris spinulosa* Complex in Eastern North America

The *D. spinulosa* complex in Europe (cf. Manton[1]) consists of three tetraploid species (*D. cristata*, *D. spinulosa* and *D. dilatata*) and the hybrids between them, together with at least one diploid previously included in *D. dilatata* but probably deserving taxonomic separation.

(1) *D. spinulosa* (O. F. Muell.) Watt. (typical)
Massachusetts—tetraploid ($n = 82$)
Michigan—tetraploid ($n = 82$)
(2) "*D. spinulosa* (O. F. Muell.) Watt. (typical)"
Massachusetts—triploid (pairs and singles)
Michigan—triploid (pairs and singles)
(3) *D. spinulosa* var. *intermedia* (Muhl.) Underw.
Massachusetts—diploid ($n = 41$)
Vermont—diploid ($n = 41$)
(4) *D. spinulosa* var. *fructuosa* (Gilbert) Trudell
Michigan—triploid (pairs and singles)
(Considered to be *D. spinulosa* (typical) × var. *intermedia*)
(5) *D. cristata* (L.) Gray
Massachusetts—tetraploid ($n = 82$)
Vermont—tetraploid ($n = 82$)
(6) × *D. boottii* (Tuckerm.) Underw.
Massachusetts—triploid (unpaired)
Vermont—triploid (unpaired)
Michigan—triploid (unpaired)
(Considered to be *D. cristata* × *D. spinulosa* var. *intermedia*)
(7) *D. cristata* var. *clintoniana* (D. C. Eat.) Underw.
Massachusetts—hexaploid ($n = 123$)
(8) *D. hybrid* (*D. cristata* × *D. spinulosa*, "typical")
Massachusetts—triploid (unpaired)
(9) *D. goldiana* (Hook.) Gray
Vermont—diploid ($n = 41$)
(10) *D. marginalis* (L.) Gray
Vermont—diploid ($n = 41$)
(11) *D. hybrid* (*D. marginalis* × *D. spinulosa* var. *intermedia*)
Massachusetts—diploid (unpaired)

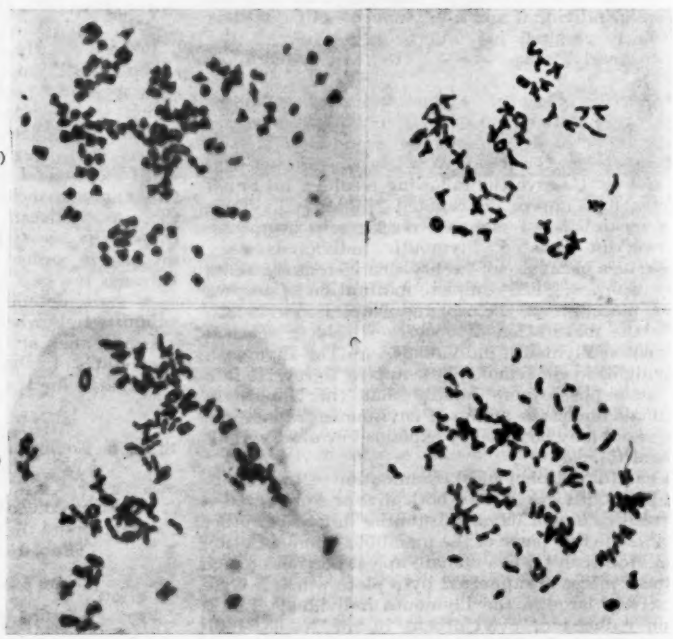
In America the situation seems to be more complicated. There are a greater number of named types, including both species and hybrids, and we have reason to think that these do not exhaust the number of cytologically distinguishable entities which exist. The above list gives some preliminary cytological observations made on wild American specimens sent to us by the kindness of Prof. R. H. Wetmore of Harvard and of Dr. W. H. Wagner, jun., formerly of Harvard and now of Michigan. The nomenclature used is that of Gray's "Manual"[2] and the identifications have been authenticated before dispatch from America by Dr. Wagner and confirmed, after completion of the cytology in Leeds, by Mr. A. H. G. Alston of the British Museum, to all of whom we are most grateful.

Commenting on this list, it should be noted that the two diploid species *D. goldiana* and *D. marginalis* placed at the end as Nos. 9 and 10 are not in themselves included in the *spinulosa* complex, but information about them is needed since they are involved in certain hybrids, notably No. 11 and perhaps No. 7.

Within the complex itself, *D. cristata* (No. 5) is the same as in Europe, namely, tetraploid. *D. cristata* var. *clintoniana* (No. 7), however, being hexaploid, is perhaps the amphidiploid hybrid between normal *D. cristata* and *D. goldiana*. We have not so far found any evidence that the European tetraploid *D. dilatata* is present in America unless it be the *D. spinulosa* var. *americana* which we have not yet examined. On the other hand, tetraploid *D. spinulosa* (No. 1) is certainly present, though the fact that some of the plants sent to us from each of two localities under this name were triploids (No. 2) suggests that there is something else breeding with *D. spinulosa* (typical) and possibly resembling it morphologically, but diploid.

We do not think that the undoubtedly diploid *D. spinulosa* var. *intermedia* (No. 3) is the form in question, since the putative hybrid between this variety and *D. spinulosa* (typical) has a different morphology which is well known under the name of *D. spinulosa* var. *fructosa* (No. 4). There is also the evidence of the putative hybrids with *D. cristata*. These are of two kinds. The wild hybrid thought to be *D. cristata* × *D. spinulosa* var. *intermedia* (No. 6) is known as *D. boottii* and, as expected, it proves to be triploid with almost complete failure of chromosome pairing. Another wild hybrid (No. 8) of different morphology was sent to us as probably *D. cristata* × *D. spinulosa* (typical). In morphology, this resembles closely the European hybrid (*D. uliginosa*) of this constitution, which is tetraploid[1]. The American hybrid is, however, yet another triploid with complete failure of chromosome pairing, suggesting that its parentage cannot involve typical *D. spinulosa* itself but could involve the unknown diploid.

We would be grateful for further supplies of American material bearing on this problem, and in the meantime the mutual relationships of American



Samples of meiotic behaviour in wild American plants of the *D. spinulosa* complex (all × 800) from permanent acetocarmine squashes prepared and photographed by S. Walker: (*a*) *D. cristata* var. *Clintoniana*, a hexaploid ($n = 123$); (*b*) *D. spinulosa* var. *intermedia*, a diploid ($n = 41$); (*c*) triploid hybrid showing pairs and singles, No. 2 in list; (*d*) triploid hybrid with almost complete failure of pairing, No. 6 in list

and European forms are being investigated by a programme of controlled breeding.

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[1] Manton, "Problems of Cytology and Evolution in the Pteridophyta" (Cambridge, 1950).
[2] Fernald, M. L., "Gray's Manual of Botany", 8th edit. (1950).

Effect of Nitrogen Mustard on an Inherited Character in the Rat

In 1949, the late P. Ellinger[1] described some experiments which suggested that treatment of rats with nitrogen mustard had produced a mutation in the gene or genes controlling the output of nicotinamide methochloride. He followed up this work with some extensive experiments, and recently asked me to analyse the results. Prof. Ellinger died before I had the opportunity of discussing with him the results of the analysis, and this communication is therefore published without the benefit of his advice.

Ellinger mated a given pair of parents twice, first without treatment, and again one day after treatment of one or both parents with nitrogen mustard (0·2 mgm./kgm. injected intraperitoneally). The daily nicotinamide methochloride output of each member of the two litters was measured. Ellinger reported four such experiments, in two of which the mean output of the offspring born after treatment of the parent was significantly lower than that of the offspring born before. Such an effect can be attributed to a gene mutation or a chromosome rearrangement only if there is, in the absence of the treatment, no litter-to-litter variation of a similar magnitude. In a genetic study of the nicotinamide methylating mechanism, Ellinger and Armitage[2] found the output to be controlled by a number of genes, but also subject to considerable environmental fluctuations. It therefore seemed possible that the changes observed in the nitrogen mustard experiments were environmental rather than genetic, and unconnected with the treatment.

The results are now available of thirty-nine non-sterile matings, in which litters were produced before and after treatment of one or both parents with nitrogen mustard. Usually, F_2 litters were produced by mating rats within the post-treatment litter, and often subsequent generations were obtained. In sixteen of the thirty-nine primary matings, the mean logarithm of output was higher in the litter produced after treatment than in that produced before, and in twenty-three the mean was lower. There is evidently no strong evidence of a systematic rise or fall in mean logarithm of output after treatment. In four matings the change in the mean logarithm of output was particularly marked (at least 0·40 logarithmic unit). Further examination of the results of these four matings suggests very strongly, however, that the changes were not genetic. In the first place, each of these changes affected the whole litter rather than (as would have been expected had a mutation occurred) an individual rat. Secondly, the output of F_2 rats, one of whose parents had an abnormally high or low output, always reverted to about the level of the treated animals and of their pre-treatment offspring. Finally, a comparison is possible with some data on untreated animals[2]. Five pairs of untreated rats each produced two litters. For four of these pairs the two litter means were very similar. In the fifth case the difference in mean logarithm of output was 0·34, a difference greater than most of those found in the nitrogen mustard experiments.

It must be concluded that the observed changes in output are probably due to environmental causes unrelated to the nitrogen mustard treatment.

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[1] Ellinger, P., *Nature*, **164**, 1095 (1949).
[2] Ellinger, P., and Armitage, P., *Biochem. J.*, **53**, 588 (1953).

Function of the Foot in the Lucinacea (Eulamellibranchia)

The Lucinacea, comprising the families Ungulinidæ, Thyasiridæ and Lucinidæ, all have a characteristically slender vermiform foot. Its anatomy has been described by Barrois[1] and Menégeaux[2] and its locomotory movements by Stoll[3]. In some species, for example, *Diplodonta rotundata*, the slightly bulbous tip is distinct from the rest of the foot. The foot can extend four or five times the length of the animal and the tip can swell out even when the foot is extended. When the foot is contracted, it lies with the tip close to the posterior edge of the anterior adductor muscle. This muscle (Fig. 1) is characteristically elongate.

These animals live in a variety of soft substrata from sand to mud, both intertidally and sublittorally, to great depths. They burrow to a depth that is equal to the length of the extended foot. All Lucinacea have anterior and posterior inhalant currents.

It has been found that, in addition to its normal movements for burrowing and locomotion, the foot forms an anterior inhalant tube lined with mucus. This has been demonstrated in *Loripes lucinalis*, *Thyasira flexuosa* and *Phacoides borealis*. This habit

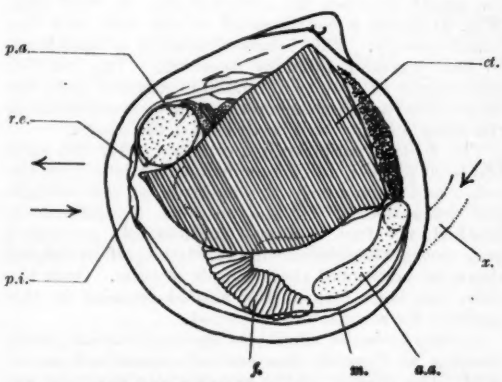

Fig. 1. *Loripes lucinalis*, with right valve removed. *a.a.*, anterior adductor; *ct.*, ctenidium; *f.*, foot; *m.*, mantle edge; *p.a.*, posterior adductor; *p.i.*, inhalant aperture; *r.e.*, retracted exhalant siphon; *x.*, position of the anterior inhalant tube

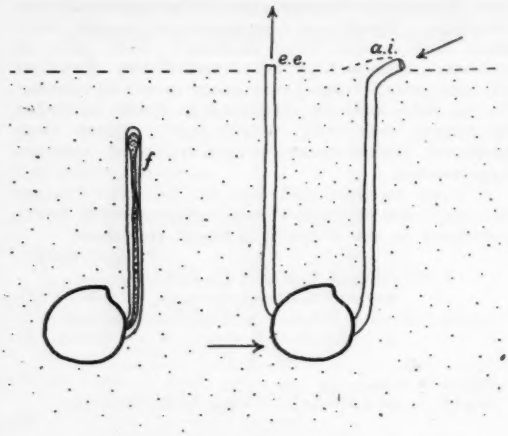

Fig. 2. Form and position of anterior inhalant tube of *Loripes lucinalis*. *f.*, foot; *a.i.*, anterior inhalant tube; *e.e.*, extended exhalant siphon

was discovered when observations were made on the burrowing mechanism of *Loripes*. The animals were allowed to burrow in specimen tubes containing sand taken from the place they were collected. Some animals came to lie by the side of the tube so that the movements of the foot could be observed. When they had buried themselves to a depth of approximately 4 cm., the foot was observed to issue from between the valves at the anterior end of the anterior adductor and gradually force its way to the surface. In these observations the foot alternately extended and contracted, each extension being longer than the last until the surface was reached. The foot secretes the mucus lining the tube. Microscopic examination of the epithelium of the foot shows numerous mucus-secreting cells which are most dense near the tip.

The tube does not open vertically to the surface but turns for two or three millimetres along the surface of the substratum (Fig. 2). After twenty-four hours, it was found that the sand could be washed from the specimen tube leaving the anterior inhalant tube intact and fastened to the glass. The tube extends from the anterior end of the anterior adductor, while the mantle between the adductor and the shell edge (Fig. 1) forms a continuation of the tube into the mantle cavity. This inhalant channel is additional to the posterior inhalant aperture. The relative importance of the two inhalant currents and the effect of the anterior one on the ciliary currents within the mantle cavity will be discussed elsewhere.

The foot is periodically protruded after the tube has been formed, and its main function is to keep the tube, and particularly the aperture at the surface, free from debris. If the entrance is deliberately blocked, the foot is almost immediately protruded and clears the obstructing particles, often laying down an additional short length of tube. Once the tube has been formed the animal remains in this position for a considerable period.

Loripes lucinalis, which was obtained from the sandy beaches at Roscoff, was carefully examined in the field. The position of the anterior inhalant tube was clearly marked in the sand by a rust-coloured deposit which also discoloured the part of the shell where the tube enters. This colour is due to fine surface sediment that has been drawn into the tube. Carmine particles were accepted, and although it was not possible to keep the specimens long enough for the tube to become discoloured, the shell in this region did become coloured with carmine.

A mucous tube is not laid down by the posterior exhalant siphon when this is present. Yonge[4] showed that in *Thracia pubescens* separate mucous tubes are formed by the siphons. In some gastropods essentially the same type of tube is formed by the proboscis. This has been demonstrated by Yonge[5] in *Aporrhais* and by Morton[6] in the Struthiolariidæ. Thus the Lucinacea show a third method of forming a mucus-lined tube.

I acknowledge the help and kindness of Prof. P. Drach and the staff of the Marine Station, Roscoff, and also of Prof. C. M. Yonge. Thanks are due to the John Murray Committee of the Royal Society for financial assistance.

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[1] Barrois, T., thesis, Faculté des Sciences de Paris (1885).
[2] Menégeaux, A., thesis, Faculté des Sciences de Paris (1890).
[3] Stoll, E., Trav. Stat. Biol. Roscoff (1938).
[4] Yonge, C. M., *Proc. Malacol. Soc.*, **22**, 337 (1937).
[5] Yonge, C. M., *J. Mar. Biol. Assoc.*, **21**, 687 (1937).
[6] Morton, J. E., *Quart. J. Micr. Sci.*, **92**, 1 (1951).

Some Relationships between Morphology and Antigenic Structure in Bacteria

The problem of correlating morphological with antigenic concepts in bacteria has made surprisingly little progress since the flagellar, capsular and somatic antigens were first recognized. Antigenic analysis has indeed required that certain somatic antigens should be regarded as occupying locations nearer or farther from the surface of the cell, but this is almost the entire extent of the concept.

Information does, however, appear to be available, which enables certain antigenic phenomena to be explained in morphological terms. The observation of Pijper[1] that somatic agglutination of typhoid bacteria occurs by the adherence of the poles of the cells, whereas in *Vi* agglutination the entire surface is affected, has a logical explanation when it is realized that the basophilic material associated with the growing-point of the cell is concentrated at the poles, where it is covered by an exceptionally thin cell wall or by none at all[2]. In Rough variants the arrangement of the growing points is entirely different, as they have a characteristic septate structure[3]. Thus we may logically assume that the secretory nucleo-proteins of the growing point represent an important somatic antigen, whereas the *Vi* antigen is a surface material.

The well-recognized fact that the Gram-positive genera constitute, as a rule, much less satisfactory antigens than the Gram-negative, can be explained in part by the fact that the former commonly have a similar septate structure to that of the Rough variants of Bacteriaceæ[3]. In this type of structure the metabolically active growing-points, and the cytoplasmic septa, which precede and secrete the cross-walls, and which appear to be similar in both function and constitution to the growing-points, are mainly internal instead of being exposed at the surface. At the same time, the cell envelopes of the Gram-

negative genera have been shown to have a higher lipid content and a much fuller range of amino-acids in the protein fraction than have those of the Gram-positives[4]. Their cytochemical behaviour more closely resembles that of intact wool proteins, whereas the Gram-positive cell envelopes resemble degraded wool proteins in this respect[5].

From these observations the following conclusions can be drawn; they are not completely proved, but must be regarded as intrinsically much more probable than the contemporary hypothesis (which most bacteriologists probably do not take very seriously) of antigenic variation by progressive loss of surface layers like the leaves of an onion. The well-known $S \rightarrow R$ variation in the pneumococcus is, of course, concerned with the loss of the capsule and is not referred to.

(*a*) The nucleoprotein material of the growing points is an important somatic antigen.

(*b*) The 'loss' of certain somatic antigens in Rough variants of Bacteriaceæ is due rather to the alteration in position of this material from a surface to an internal site than to its actual disappearance.

(*c*) The loss of further somatic antigens in Rough variants, and the low antigenicity of Gram-positive genera, are due to the chemically simpler structure of the cell envelopes in bacteria of septate morphology.

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[1] Pijper, A., *J. Path. Bact.*, **47**, 1 (1938).
[2] Bisset, K. A., *J. Gen. Microbiol.*, **5**, 155 (1951).
[3] Bisset, K. A., "The Cytology and Life-History of Bacteria" (Edinburgh, Livingstone, 1950); "Bacteria" (Edinburgh, Livingstone, 1952).
[4] Salton, M. R. J., and Horne, R. W., *Biochim. Biophys. Acta*, **7**, 177 (1951). Salton, M. R. J., *Biochim. Biophys. Acta*, **9**, 334 (1952).
[5] Fischer, R., and Larose, P., *Canad. J. Med. Sci.*, **30**, 86 (1952).

Sporulating Anaerobes on English Flax

Allen[1] reported that the majority of spore-bearing anaerobes isolated in pure culture from anaerobic and aerobic flax-rets in England, and which appeared usually to be the active agents in retting, possessed the characteristics of *Clostridium tertium*. Dowson[2] found that *Bacillus polymyxa*, a facultative sporulating organism, was capable of causing a soft rot of potato. This organism is capable of attacking pectin and therefore has potential retting abilities. *B. amylobacter* Bredemann, which is a synonym of *Cl. butyricum* and wrongly includes more than one true specific group[3], is mentioned in the literature as a retting organism[4]. So far as I am aware, no other strict anaerobe, facultative anaerobe or micro-aerophilic organism has been reported in England as a possible retting agent.

In other leading flax-retting countries, however, *Cl. pectinovorum*, a plectridial anaerobe, and *Cl. felsineum*, an orange-pigmented anaerobe, are considered to be the major retting agents, the latter being superior to the former. *Cl. tertium* has not been cited, except by Lanigan[5], who observed that a micro-aerophilic species related to *Cl. tertium* but differing from the latter in that it liquefied gelatin was most commonly found on Australian flax. *B. polymyxa*, if found, is considered of minor importance. Hellinger[3] found *Cl. aurantibutyricum*, an orange-pigmented butyric acid-producing organism, and *Cl. pectinovorum* var. *pseudoplectriforme*, to be commonly distributed in Israel flax rets. *Cl. aurantibutyricum* proved to be a highly efficient retting organism comparable to *Cl. felsineum*.

I have recently been investigating the microbial flora, more especially the sporulating anaerobes, on samples of English flax from Norfolk, Suffolk and Wiltshire. Straw samples were placed under simulated retting conditions, that is, immersed in water at 32° C., and sporulating anaerobes were isolated in pure culture using maize mashes, yeast–glucose–chalk media and potato/yeast–glucose agar slants in test-tubes under anaerobic conditions. A micro-aerophilic plectridial organism classified as *Cl. pectinovorum* (of. Weizmann and Hellinger[6]), and *Cl. butyricum* were invariably present and numerous in all samples. An orange-pigmented anaerobe was found; but it formed a small part only of the flora of some of the flax. It was identified as *Cl. aurantibutyricum*, and not *Cl. felsineum*. *B. polymyxa* was obtained, but it was present in extremely small numbers.

The English isolates of *Cl. pectinovorum* were compared with a typical strain of the organism obtained from Prof. Kluyver of Delft, and a strain of *Cl. tertium* (541) obtained from the National Collection of Type Cultures. Studies carried out with these organisms tend to show that *Cl. tertium* is identical with *Cl. pectinovorum*. The strains examined were micro-aerophilic and also liquefied gelatin, the former a feature characteristic for *Cl. tertium*, the latter a distinguishing feature of *Cl. pectinovorum*.

The flax-retting abilities of the organisms isolated were tested on sterilized flax straws according to the method of Hellinger[3]. The new isolates of *Cl. aurantibutyricum* were remarkably active. Retting progressed moderately well after 48–54 hr. and the fibre bundles were completely liberated from the stem matrix after 66 hr. None of the strains of *Cl. pectinovorum*, including also the Dutch strain and *Cl. tertium* (strain 541), showed any sign of retting in 6–11 days at 32° C. Continuous aeration was tried, but also gave negative results. The *Cl. butyricum* isolates were also ineffective, whereas *B. polymyxa* caused a certain amount of loosening of the fibre bundles.

It is perhaps possible that *Cl. tertium* (strain 541) and the Dutch strain of *Cl. pectinovorum* had lost their original retting ability on long-continued artificial cultivation.

Full details of this work will be given elsewhere. It was done while on leave from the Weizmann Institute of Science, Rehovoth, Israel. Grateful acknowledgments are due to Mr. Gillham, Directorate of English Flax Production of the Ministry of Materials, and Major Searle, director of H.M. Norfolk Flax Establishment, King's Lynn, for their ready co-operation in giving me laboratory facilities and assistance.

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[1] Allen, L. A., *Nature*, **157**, 829 (1946).
[2] Dowson, W. J., *Nature*, **152**, 331 (1943).
[3] Hellinger, E., *Bull. Res. Counc. Israel*, **2** (1952).
[4] Galloway, L. D., and Burgess, R., "Applied Mycology and Bacteriology", 127 (Leonard Hill, London, 2nd edit., 1940). The Flax Development Committee, Sixth Interim Report, 1945, p. 76.
[5] Lanigan, G. W., *Nature*, **165**, 516 (1950).
[6] Weizmann, Ch., and Hellinger, E., *J. Bact.*, **40**, 665 (1940).

Rooting of Cut Shoots of Cotton in Culture Filtrate of *Fusarium vasinfectum*

A study was made of the toxicity of culture filtrates of the cotton-wilt pathogen, *Fusarium vasinfectum* Atk., grown in synthetic Czapek's medium, to cut shoots of cotton. This indicated that, under laboratory conditions, the culture filtrate (fourteen days old) when dialysed against distilled water at 4–5° C. for four days to rid the crude filtrate of metabolites—earlier observed to be toxic to the plant—brought about typical wilt symptoms, which have been described in detail elsewhere[1]. Higher dilutions of this dialysed neat filtrate did not produce any symptoms of toxæmia, but induced rooting. However, the dialysed filtrate autoclaved at 15 lb. pressure for 15 min. (with the view of inactivating the toxin) induced profuse rooting in the cut shoots of cotton at all concentrations, and in no case were there any typical wilt symptoms.

These observations indicate that the dialysed culture filtrate of *F. vasinfectum* probably contains two or more factors: (i) a thermolabile factor producing wilt symptoms at higher concentrations; and (ii) a thermostable factor stimulating vigorous rooting in the cut shoots even at dilutions. It is likely that the latter factor is ineffective in the presence of higher concentrations of the former, since at these concentrations of the neat dialysed filtrate only typical wilt symptoms are produced, but not rooting.

So far as we are aware, stimulation of rooting of cut shoots of cotton plants by dialysed fungal filtrates has not been previously reported, and it is therefore considered worth while to record this interesting phenomenon. Detailed work on the nature of the factor or factors contained in the dialysed filtrate and their interaction with each other and also their effects on cut shoots of different host plants are now under way, and the results of these investigations will be reported in detail elsewhere.

We thank Prof. T. S. Sadasivan and Dr. C. V. Subramanian for their suggestions and guidance.

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[1] Satyanarayana, G., and Kalyanasundaram, R., *Proc. Ind. Acad Sci.*, B, **36**, (2), 54 (1952).

High Molybdenum Levels in Herbage on Acid Soils

It is generally considered that there is a marked correlation between molybdenum uptake by plants and soil reaction. Evans *et al.*[1] and others have shown that a change in reaction from strongly acid to alkaline results in increased uptake, especially in the alkaline region. So far as we are aware, all cases of molybdenum deficiency hitherto reported have been in acid soils, while excess levels of molybdenum in herbage, responsible, in part at least, for complicated copper-deficiency effects in livestock, have been reported only from slightly acid to strongly alkaline soils. This in general has also been our experience[2]. However, in an extension of our work, a case has been found where the conditioned copper-deficiency syndrome occurs in cattle confined to pasture growing on strongly acid soils. It was thought at first that this might possibly be a case of simple copper-deficiency. The animals were severely affected. Blood samples showed copper values varying from 0·03 to 0·07 mgm. per cent. Herbage samples taken from the pastures concerned showed copper values in the region of 13 parts per million and molybdenum values of 7·0–13·0 p.p.m. The herbage consisted of bent grasses, crested dogstail, Yorkshire fog, *Juncus* spp., sedges and other species typical of poor pasture on acid soils.

The soil in the area concerned, while situated on the slope of a drumlin, is moderately impeded. The surface soil (0–8 in.) is a grey-black silt loam and overlies a grey, slightly mottled brown, plastic clay loam sub-soil. Representative soil samples showed a *p*H varying from 4·9 to 5·2 with a calcium exchange-level of 5 m. equiv. and hydrogen exchange-level of 14 m. equiv. per 100 gm. Organic carbon averaged 12 per cent. These samples also showed very low levels of available potash and phosphate. The total molybdenum content varied from 2·1 to 3·00 parts per million, with a readily available level of 0·80–0·90 p.p.m., as determined by Griggs's oxalate method. These are the highest readily available molybdenum levels so far recorded by us, a threshold value for excess levels in slightly acid to alkaline soils being 0·30 p.p.m.[3].

The fact that there has been a relatively high uptake of molybdenum by herbage plants in these strongly acid, low calcium soils is consistent with the finding of Stout *et al.*[2], who, using culture solutions, showed that absorption of molybdenum by plants is far greater from acid soils than from soils of neutral reaction. It is possible that in the soils investigated by us the agents responsible for the fixation of molybdenum may be absent, and it is thought likely that this may be associated with the reduced condition of the soil and its organic matter content. This aspect of the problem is being investigated. The experience obtained indicates that it is desirable to extend considerably the range of soil conditions, especially where reaction is concerned, under which excess molybdenum uptake by herbage may be expected.

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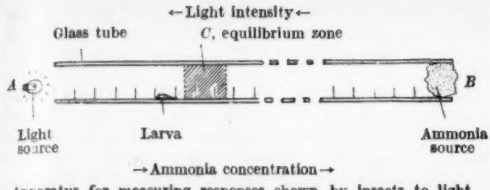
[1] Evans *et al.*, *Soil Sci.*, **71**, No. 2 (1951).
[2] Stout, P. R., *et al.*, *Plant and Soil.*, **3** (1951).
[3] Walsh, T., *et al.*, *Nature*, **170**, 149 (1952); *J. Dept. of Agric.*, Ireland, **48** (1952).

A Simple 'Response Balance' for studying Insect Behaviour

The responses shown by insects to insecticides are usually measured in terms of paralysis or death. Since the insects lose their power of co-ordinated movement during the primary stages of poisoning, they cannot respond to stimuli which modify their normal behaviour. When the concentration or dosage of insecticide is very low, however, insects may be irritated or repelled by the insecticide without loss of muscular co-ordination. Under such conditions the responses shown to other stimuli, for example, a light stimulus, become of interest, especially where the



Apparatus for measuring responses shown by insects to light and chemical stimuli

kinetic effects of the chemical and light stimuli are opposed. In the present communication, a description is given of an apparatus, or 'response balance', used for studying systems of this kind (see diagram).

The apparatus consisted essentially of a glass tube 24 in. long and 1 in. internal diameter. A 60-watt lamp connected to a variable resistance was placed near end *A*, and a plug of cotton wool soaked in the repellent was inserted in *B*. The apparatus was used in a dark room at 20° C.

In a typical experiment, mature *Calliphora* larvæ, which are negatively phototropic, were used as test insects; the source of repellent vapour was a strong ('880') solution of ammonia. Five larvæ were placed in the tube at *A* and the light intensity gradually increased until the larvæ started crawling towards the ammonia source. With increasing concentration of ammonia vapour the repellent stimulus became stronger, and the larvæ frequently turned round towards the light, then back towards the ammonia source. At this stage the light source was kept constant; the larvæ crawled about at random within restricted equilibrium zones (*C*), 2–3 in. in length, where the kinetic effect of the light stimulus balanced that of the chemical stimulus. When the light source was dimmed, the chemical repellent stimulus became the dominant factor, and the larvæ crawled towards the light, the equilibrium zones being displaced in this direction; the effect was reversible, the larvæ moving towards the ammonia source when the light was made brighter.

Sensitizing effect of kerosene on chemoreceptors. The sense organs of insects are bounded by a thin cuticular sheath[1]. Since it was known that oils, such as kerosene, greatly increase the permeability of the cuticle of *Calliphora* larvæ to a variety of chemical substances and insecticides[2], experiments were tried to see whether kerosene might sensitize the chemoreceptors in this insect to ammonia vapour. The above experiment was repeated using (*a*) five mature larvæ as controls, and (*b*) five mature larvæ which had been lightly painted with kerosene. Values obtained to the nearest inch for the distance *B–C* between the ammonia source and the mid-point of each equilibrium zone were:

controls, 8, 7 7, 5, 4 in.;
oiled larvæ, 17, 14, 13, 12, 10 in.

A similar experiment was carried out in which test larvæ were painted with medicinal paraffin instead of kerosene. Values obtained for *B–C* were:

controls, 9, 7, 6, 6, 4 in.;
oiled larvæ, 11, 8, 6, 5, 5 in.

The observations that kerosene, but not medicinal paraffin, sensitizes *Calliphora* larvæ to the repellent action of ammonia vapour suggest that chemoreceptors stimulated by ammonia are made more sensitive by an increase in cuticle permeability. A similar difference between the effects of these oils on the uptake of contact insecticides had already been correlated with their relative dispersive actions on the lipids of the outer fatty epicuticle bounding the bulk cuticle framework[3].

Lethal effect of ammonia vapour. When the light source was made very intense, control and kerosene-treated larvæ crawled nearer to the ammonia source until they began to roll about at random, showing a loss of neuro-muscular co-ordination. There were no sharply defined equilibrium zones, and when the light was dimmed the larvæ did not crawl away from the ammonia source as observed for larvæ in contact with lower concentrations of ammonia vapour. Within a few minutes the larvæ became paralysed; they were removed from the tube and kept in open Petri dishes, where they died within 10–15 hr. The initial kinetic effect of the light stimulus was thus greater than that of the opposing chemical stimulus, even though the larvæ moved into a lethal concentration of ammonia.

Although irritant vapours, such as ammonia, may stimulate a variety of sensory endings in insect cuticle[4], the sensitizing effect of kerosene on these receptors suggests that fatty components similar to those in the bulk epicuticle may act as a protective barrier in the cuticular sheaths of sensilla, including those which act as more specific organs of smell and taste. This view may have some bearing on the findings of Dethier and Chadwick[5] that the lipid solubility of different chemical substances is related to their stimulating activity on the tarsal organs of taste in *Phormia*.

This report is based on work begun at the Department of Zoology, Imperial College of Science and Technology, and continued at the Department of Colloid Science, Cambridge. A full account will be given elsewhere.

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[1] Ruland, F., *Z. wiss. Zool.*, **46**, 602 (1888).
[2] Hurst, H., *Nature*, **145**, 462 (1940); Discuss. Farad. Soc., No. 3, 193 (1948); *J. Exp. Biol.*, **27**, 238 (1950).
[3] Hurst, H., *Nature*, **152**, 400 (1943).
[4] Valentine, J. M., *J. Exp. Zool.*, **58**, 165 (1931).
[5] Dethier, V. G., and Chadwick, L. E., *Physiol. Rev.*, **28**, 220 (1948).

Significance of Nannoplankton

Atkins[1], in 1945, reported on the productivity of the English Channel as estimated by two independent methods. The silicate turnover indicated a far lower productivity than did the phosphate turnover, and from this he deduced that only a relatively small fraction of the phytoplankton could consist of forms with siliceous skeletons. Knight-Jones and Walne[2] later showed that the very small nannoplanktonic form, *Chromulina pusilla*, was present in English Channel waters in numbers averaging about 1,000 per ml. They quoted other work showing that as much as 90 per cent of the phytoplankton may be small enough to pass through a fine silk tow net, and 40 per cent through a No. 2 Whatman filter paper.

The Florida current off Miami was sampled for a period of one year, and the phytoplankton content, as indicated by metered Clarke–Bumpus No. 20 net hauls, was compared with the results from samples filtered through a No. 54 Whatman filter paper. The results are shown in the accompanying table.

PHYTOPLANKTON CONTENT OF FLORIDA CURRENT WATER IN HARVEY UNITS PER CUBIC METRE
In this area, one H.U. is approximately equivalent to 0·017 mgm. of organic carbon

Net haul	Paper-filtered	Filtered / Net
0·42	401	955
0·61	448	734
0·87	1,380	1,586
4·68	6,750	1,442
5·60	1,660	296
6·10	657	108
6·37	7,950	1,248
6·70	1,540	230
7·65	9,220	1,205
17·8	20,000	1,124
18·7	23,350	1,249
19·7	20,950	1,063
59·1	57,600	975
		Mean 937

In this area, then, the nannoplankton is rather consistently about a thousand times as rich as the fraction of the phytoplankton which can be captured with a net. While the ratio appears very high, it may be pointed out that Hart[3] demonstrated a great increase in the proportion of armoured dinoflagellates in lower latitudes as compared with antarctic seas. Between 60° and 40° S., they averaged only 7 per cent of the phytoplankton, whereas between 40° and 20° S. they averaged 63 per cent. If the nannoplanktonic forms are considered to be largely unarmoured dinoflagellates, then it is not unexpected that they should constitute a high proportion of the phytoplankton in warmer waters. In any event, it is clear that net hauls provide a quite inadequate picture of the standing crop of phytoplankton.

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[1] Atkins, W. R. G., *Nature*, **156**, 446 (1945).
[2] Knight-Jones, E. W., and Walne, P. R., *Nature*, **167**, 445 (1951).
[3] Hart, T. J., "Discovery" Rep., **8**, 1 (1934).

Hormonal Nature of Extracts of Parathyroid Gland stimulating Phosphate Excretion

Stewart and Bowen[1] have recently reported that preparations of parathyroid hormone after treatment with formaldehyde lose their power to raise the serum calcium-level of dogs, while still remaining able to increase the excretion of urinary phosphate. In view of these results, we wish to report on the properties of certain extracts obtained from ox parathyroid glands by a different method.

In our work acetone powders, made from frozen glands by the method of Tepperman, L'Heureux and Wilhelmi[2], have been extracted at 75° with 15 parts of 80 per cent acetic acid. After 5 min. at this temperature, heating was stopped and extraction was continued for 1½ hr. Mechanical stirring was maintained throughout. After centrifugation and removal of most of the acetic acid *in vacuo*, such extracts were dialysed for one week at 0° against a large volume of dilute acetic acid. Both the material which remained inside and that which passed through the membrane were tested by subcutaneous injection into parathyroidectomized rats. After appropriate times, the resulting changes in serum calcium[3], serum phosphate or urine phosphate[4] were measured.

The results of such tests summarized in the accompanying table show that, like Stewart and Bowen, we have succeeded in obtaining material from the parathyroid gland which is able to increase the excretion of phosphate in the urine without having any direct effect on the serum calcium-level. Because at least some of the phosphate-stimulating material in our 80 per cent acetic acid extracts consists of molecules small enough to pass through a 'Cellophane' membrane, we have not had to resort to the use of a protein denaturing agent such as formaldehyde to achieve dissociation of the two activities. Whether the parathyroid gland normally secretes a single molecular species active in relation to the blood-level, and the excretion, of both calcium and phosphate remains one of the most interesting questions for the future. Alternatively, it may possibly be that the hydrochloric acid – acetone procedure of Tepperman *et al.* leads to an association of originally separate molecules.

TESTING OF PARATHYROID EXTRACTS

Extract	Increase in serum calcium	Increase in urine phosphate	Decrease in serum phosphate	Increase in serum calcium	Increase in urine phosphate
	Material which had passed through 'Cellophane' membrane			Material unable to pass through membrane	
A		+ (0·04)			+ (0·4)
B		+ (0·4)			
C	No change (40)		+ (1·2)	+ (81)	
*D**	No change (57)			+ (10)	

Amount of material injected per rat (mgm.) is shown in brackets. Average number of animals used per test: urine phosphate 56, serum phosphate 32, and serum calcium 14. Since there were large differences between the responses of individual rats in the serum and urine phosphate experiments, rather large numbers of animals had to be used. In these tests all the results were significant, $P < 0{\cdot}02$. The serum calcium of the rats used to test the diffusible material showed an average fall of 5 per cent (due to taking blood samples) whereas the non-diffusible material caused an average rise of 16 per cent.
* Extract *D* was made by extracting under similar conditions but for 50 min. instead of 5 min.

In view of the above separation of the phosphate activity from that concerning calcium metabolism, it is of interest to consider whether the effect of the parathyroid gland on phosphate metabolism is due to a hormone or to a non-specific factor. That such a hormone exists, either as part of the calcium-active hormone or as a separate molecular species, is suggested by the observation of Engfeldt[5] that after parathyroidectomy the serum inorganic phosphate of rats rises for a few days and then remains steady at a level some 2 mgm. per cent higher than that before operation. Even more important is the finding of Tweedy, Chilcote and Patras[6] that the urinary phosphate excretion of rats becomes very sensitive to parathyroid hormone immediately after parathyroidectomy. We have recently confirmed that result and have observed that the increased sensitivity does not diminish for several weeks after operation. Corresponding falls in serum inorganic phosphate have also been noted after amounts of hormone so small as to cause only very slight decreases in the normal rat.

Despite these points, Stewart and Bowen do not suggest that the phosphate-eliminating effect is due to a hormone, their reason being that they extracted phosphate-eliminating material from both thymus and spleen by the same method as that used by Tepperman *et al.* for preparation of the parathyroid hormone. They consider rather that extracts of all

three glands are able to stimulate the excretion of phosphate by virtue of their content of "pharmacologically active tissue degradation products".

Although there is not as yet sufficient evidence for the secretion by the thymus or spleen of a hormone effecting phosphate metabolism, the facts summarized above on the results of extirpation of the parathyroid would seem to show that this gland at least secretes a factor necessary for the maintenance of normal phosphate excretion. Although the method of extraction of thymus and spleen used by Stewart and Bowen no doubt yielded a preparation consisting largely of protein, it is of interest that Nitschke[7] prepared extracts of thymus and spleen having fatty properties which were found markedly to depress the serum inorganic phosphate of dogs. While such material if present as lipoprotein could presumably explain Stewart and Bowen's results, it would appear to have different physico-chemical properties from the phosphate-eliminating extract prepared by us from parathyroid glands. The most important conclusion seems to be that the excretion of inorganic phosphate by the kidney is under the control of a hormone secreted by the parathyroid. Whether the extracts of other glands which have been shown to have activity in this respect contain the same or similar hormones or only non-specific factors remains to be determined. However, it seems certain that whatever the role of the factors derived from other tissues, the secretion of the parathyroid must be quantitatively of considerable importance since extirpation of this gland causes marked effects.

Finally, it should be noted that although, so far as the phosphate effect is concerned, the products of parathyroid and thymus seem to act in the same sense, this is probably not true in relation to their effects on serum calcium. Thus Nitschke[7] has reported extracts of thymus and spleen insoluble in fatty solvent, which he claimed led to a lowering of serum calcium. It would clearly be of interest to know what effect, if any, Stewart and Bowen's thymus extracts have on serum calcium.

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[1] Stewart, G. S., and Bowen, H. F., *Endocrinol.*, **51**, 80 (1952).
[2] Tepperman, H. M., L'Heureux, M. V., and Wilhelmi, A. E., *J. Biol. Chem.*, **168**, 151 (1947).
[3] Biering, A., "Bioassay of Parathyroid Hormones on Rats" (University Press, Aarhus).
[4] Davies, B. M. A., and Gordon, A. H., *J. Endocrin.* (in the press).
[5] Engfeldt, B., *Acta Endocrinol.*, **5**, Supp. 6, 75 (1950).
[6] Tweedy, W. R., Chilcote, M. E., and Patras, M. C., *J. Biol. Chem.*, **168**, 597 (1947).
[7] Nitschke, A., *Z. Ges. Exp. Med.*, **65**, 637 (1929).

Asparagine in Blood Plasma

FREE asparagine has twice before been reported in animal tissues, namely, in the liver, kidney and spleen of sheep[1], and, recently, in human urine[2]. The evidence given below shows that it is also present in the blood plasma of both man and the goat: the concentrations are, in fact, comparable to those of many other free amino-acids in blood plasma.

If an amino-acid mixture is analysed by chromatography on 'Dowex-50' resin exactly as described by Moore and Stein[3], but at 20° C. instead of 37·5° C., glutamine and asparagine emerge as a single peak. When a blood plasma dialysate is heated to 100° C. at *p*H 6·5 for two hours so as to remove glutamine and then subjected to chromatography by this procedure, a ninhydrin-reacting peak still appears in the glutamine–asparagine range. If this fraction is heated to 100° C. with 2 *N* hydrochloric acid for three hours, or incubated at *p*H 7·0 and 30° C. for three hours with 1 ml. of guinea pig serum, which, unlike other mammalian sera contains an asparaginase enzyme[1], then, after chromatography, an equivalent amount of ninhydrin-reacting material appears in the aspartic acid range. When the material in the asparagine range is run through a column of 'Dowex-50' with 0·5 *N* hydrochloric acid as eluent it emerges as a peak in the same position as known samples of asparagine; if, on the other hand, the material is first hydrolysed with hydrochloric acid, then peaks emerge in the positions of aspartic acid and ammonia. When the fraction in the asparagine range is deionized and subjected to paper chromatography with aqueous phenol, a single spot is obtained in the position of asparagine; if the material is first hydrolysed with hydrochloric acid a spot is obtained in the position of aspartic acid. The material in the asparagine range when reacting with ninhydrin either in solution or after paper chromatography always gives the delayed colour production which is typical of asparagine.

The concentrations of asparagine in blood plasma samples from four men were 1·4, 1·3, 1·3 and 1·0 mgm./100 ml. The average of the concentrations in five plasma samples from a single goat was 0·95 mgm./100 ml. The concentration of asparagine is thus of the same order as the concentration of many other free amino-acids in plasma.

I am grateful to Dr. D. G. Jamison for his co-operation in obtaining the samples of human blood.

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[1] Krebs, H. A., *Biochem. J.*, **47**, 605 (1950).
[2] Stein, W. H., *J. Biol. Chem.*, **201**, 45 (1953).
[3] Moore, S., and Stein, W. H., *J. Biol. Chem.*, **192**, 663 (1951).

Some Histochemical Observations on Periodic Acid – Amino-Acid Mechanisms

THE periodic acid Schiff technique has been used histochemically primarily as a means of localizing the 1,2 glycol linkage in tissue sections[1]. It is known, however, that periodic acid is also capable of cleaving the 1,2 hydroxylamino linkage with the production of some aldehyde radicals, and although the exact reaction mechanism is not understood, it is believed by some to react in a somewhat similar manner with a number of amino-acids possessing structurally neither of these linkages. The amino-acids serine and threonine, as well as the "hydroxylysine" of Van Slyke, fall into the first category, whereas cystine, methionine, tryptophane, glycine, alanine, tyrosine, histadine, aspartic and glutamic acids fall into the latter group[2]. This investigation was initiated to study specifically this phase of the periodic acid Schiff mechanism, and although the results were not conclusive, it was felt that a brief description of the experiments might be of interest to others working in this particular field.

Two series of experiments were prepared, one utilizing paraffin-prepared tissue sections from formalin, alcohol and Bouin-fixed blocks of rat, rabbit and human spleen, liver, intestine, cardiac and skeletal muscle, the other using amino-acid impregnated agar and gelatin blocks. These sections and blocks were oxidized in aqueous periodic acid under varying conditions of concentration, time and temperature. The sections were then processed by the McManus periodic acid Schiff technique[3], and the blocks were similarly tested for the presence of aldehyde radicals[4]. The sections, after staining, were compared with routinely stained periodic acid Schiff control sections and with sections stained by the alloxan, ninhydrin, Millon, Axenfeld and xanthoproteic protein localization techniques[5]. It was hoped that in this way correlation could be obtained between the normal protein localization picture and any protein (amino-acid) localizations obtained with intensified periodic acid oxidation. The impregnated blocks were similarly oxidized, and colour development with leucofuchsin was checked against impregnated – unoxidized, unimpregnated – oxidized and unoxidized – unimpregnated control blocks. The sections and blocks were oxidized at 27° C. for periods up to six weeks in 0·5 per cent periodic acid, up to 24 hr. in varying acid concentrations at temperatures up to 60° C., and for periods up to one week at 27° C. in periodic acid concentrations up to 6 per cent.

As previously noted, these experiments were essentially empirical. After 10 min. oxidation in 6 per cent periodic acid at 27° C. or at 60° C. in a 0·5 per cent solution, leucofuchsin coloration was apparent in non-polysaccharide tissue components. A sequence of reaction seemed evident with prolonged oxidation. Initially, the tissue glycol components stained, the intensity increasing with additional oxidation. Non-polysaccharide components became leucofuchsin-positive more slowly, reaching a maximum coloration after several hours oxidation. If oxidation was prolonged, there developed a gradual decrease in coloration in the glycol components, followed more slowly in the non-polysaccharides. After very prolonged oxidation (four days in 0·5 per cent acid at 27° C.) a diffuse non-specific stain was obtained, giving some indication of a gradual destruction of the aldehyde radicals initially produced by the oxidation, such as has been suspected in histochemical chromic acid oxidations. At the peak of their intensity, these non-glycol colorations stained strongly the same tissue components demonstrated by the protein-localization technique, superimposed, of course, on an intense glycol-localization picture. The correlative value of the impregnated blocks was minimal, due to erratic behaviour, although many cases of definite aldehyde production were present after oxidation. Although serine and threonine gave positive coloration after 5 min. in 0·5 per cent acid at 27° C., the results of this phase of the experiment were too non-specific for positive confirmation of periodic acid demonstration of amino-acids in general.

Even though no specific conclusions can be drawn from these experiments, one point is apparent. When tissue carbohydrates are localized by the periodic acid Schiff method, it should be remembered that although a carefully controlled reaction probably reacts only with 1,2 glycols to form aldehyde radicals, this specificity may well be destroyed by excessive oxidation with involvement of amino-acids, especially those containing hydroxylamino linkages. This possibility should be kept in mind when utilizing the periodic acid Schiff procedure.

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Dec. 12.

[1] Hotchkiss, *Arch. Biochem.*, **16**, 131 (1948).
[2] Basic chemical references to this problem can be obtained by request from the author.
[3] McManus, *Stain Tech.*, **23**, 99 (1948).
[4] Lhotka, J., *Nature*, **170**, 751 (1952).
[5] Lison, "Histochimie Animale" (Gauthier-Villars, Paris, 1936).

Kinetics of Reaction in Ethanol Solution from −80° C. to +20° C.

Rates of reaction in solution have not usually been measured over a range of temperature greater than about 50° C. Measurements over a bigger range would give more accurate values of the energy and entropy of activation, and interesting deviations from the linear Arrhenius relation between $\log k$ and $1/T$ might be expected, especially in proton-transfer reactions[1]. We have measured the rate between − 80° C. and + 20° C. of the reaction between ethoxide ion and trinitrotoluene in ethanol, which appears to proceed by a proton transfer:

$$C_6H_2(NO_2)_3CH_3 + EtO^- \rightarrow EtOH + [C_6H_2(NO_2)_3CH_2]^-.$$

The ion produced is coloured and the reaction can be followed photometrically. At room temperature, rates were measured on a rapid-reaction apparatus of the Hartridge–Roughton type using the 'stopped-flow' method[2]; the fastest reaction observed had a half-period of 0·2 sec. At the lower temperatures a thermostat using solid carbon dioxide as refrigerant was employed. The observed velocity constants covered a range of more than 5 powers of 10.

The relation between $\log_{10} k$ and $1/T$ is linear within experimental error over the whole temperature range, as the accompanying table shows. In this table we compare the observed values of the velocity constant k, expressed as $k = 10^n k'$, with the values calculated from the equation $k = 1{\cdot}026 \times 10^{12} \exp(-13{,}600/RT)$ mole litre^{-1} sec.$^{-1}$. It will be seen that the deviations are random in direction and not too large compared with the estimated experimental errors.

T (°C.)	+19·1	−30·0	−40·0	−50·0	−60·0	−70·0	−78·5
n	+ 1	− 1	− 1	− 2	− 2	− 3	− 4
k' (calc.)	6·34	5·52	1·64	4·40	1·03	2·12	4·84
k' (obs.)	6·30	5·61	1·64	4·42	1·00	2·18	4·58
% diff.	+ 0·6	− 1·6	+ 0·0	− 0·5	+ 3·0	− 2·8	+ 5·7
Est. exp. error	± 3	± 1·5	± 1	± 1	± 3	± 3	± 5 %

This implies that the energy of activation E is constant within the limits of experimental error, and certainly within 100 cal./mole, at 13,600 cal./mole. A change in the value assumed for E of so little as 40 cal./mole leads to a definite trend in the difference between observed and calculated results. The A-factor can be given with corresponding accuracy: $\log_{10} A = 12{\cdot}0 \pm 0{\cdot}1$, with A in sec.$^{-1}$.

The constancy of E implies that the value of ΔC_p in the expression $E_{(T°C.)} = E_{(-80°C.)} + \Delta C_p(T+80)$ is too low to be detected. A low value of ΔC_p would be expected for this reaction, since the difference

between the specific heats of the transition complex and the reactants will be mainly due to any changes of solvation that occur on forming the transition complex, and these depend largely on the change of charge, which is here zero. Moreover, these changes of solvation would also be reflected in the entropy of activation, and so in an abnormal A-factor; and for this reaction A is nearly normal.

This work will be reported in full elsewhere.

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Jan. 13.

[1] Bell, R. P., "Acid-Base Catalysis", chapter 8 (Oxford, 1941).
[2] cf. Chance, *J. Franklin Inst.*, **229**, 455, 613, 737 (1940).

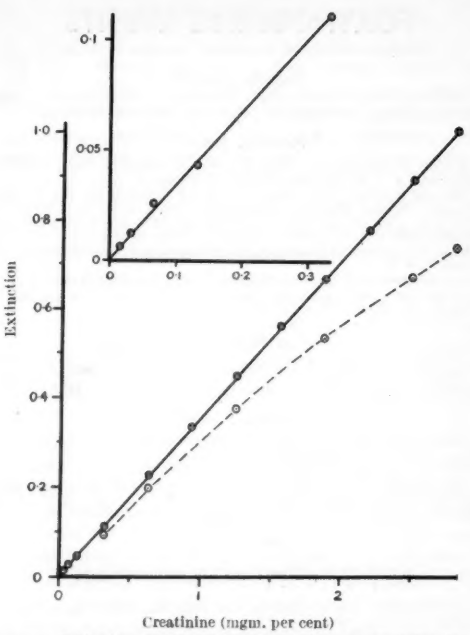
Determination of Creatinine by the Jaffé Reaction

It has often been stated that the colour-producing reaction between creatinine and alkaline picrate does not obey Beer's law[1-3]. This implies that a calibration graph relating creatinine concentration to light extinction is not a straight line. Curves have been obtained with photoelectric absorptiometers using filters which pass an appreciable band of wave-lengths, for example, 495–550 mμ [4].

Beer's law, however, is only strictly true for monochromatic light[5]. It does not appear to be generally known that an instrument measuring on a very narrow band of wave-lengths gives a linear calibration graph for creatinine, although Borsook and Dubnoff[6] mentioned this fact in describing their method for estimating creatine. The accompanying graph was plotted from readings obtained with a Beckman spectrophotometer for a series of dilutions of a standard solution of creatinine zinc chloride. The modification of the Jaffé reaction published by Bonsnes and Taussky[1] was employed, but the linearity is not peculiar to this particular method. Within the limits of probable volumetric and reading errors, the points fall on a straight line over the range of concentrations which can be read satisfactorily.

The wave-length 520 mμ seems to be the most convenient to use. At longer wave-lengths the sensitivity decreases. At shorter wave-lengths the sensitivity is greater; but this is not an advantage, because at 520 mμ it is already sufficient for the accuracy of the method as a whole. Although the anomalies in light absorption at low concentrations of creatinine reported by Garner[3] suggest that below 515 mμ the relationship would not be linear, similar graphs were in fact obtained at 490 mμ and at 480 mμ, the range of concentrations which could be read being about half as great as at 520 mμ. There was no evidence of any systematic departure from linearity, but apparently fortuitous deviations at low concentrations (see inset graph) became relatively greater, or appeared for the first time, as the wave-length was reduced. The slit-width had to be increased to work at the shorter wave-lengths.

The calibration graph is reproducible if the conditions are kept constant, but this may be difficult to achieve. It has been found that the time for which the colour is allowed to develop before reading is not critical within the limits given by Bonsnes and Taussky, but the temperature of the solutions at the time of reading does have an appreciable effect.



——— Calibration graph for standard solutions of creatinine zinc chloride read with the Beckman spectrophotometer. $\lambda = 520$ mμ; slit-width, 0·04 mm. Inset: lower part of the graph drawn on expanded scales. Concentrations refer to creatinine base in the solutions, after diluting but before adding alkaline picrate. The lowest point corresponds to a creatinine concentration about a tenth of that found in a normal serum filtrate. — — —, Calibration curve for the same solutions read with a 'Spekker' absorptiometer, with Ilford 604 filters (nominal band-width 500–540 mμ)

Rather than standardize these and other variables, it is probably simpler to read one or more known solutions with each batch of unknowns, the linearity of the graph then enabling it to be drawn for the conditions prevailing at the time. If the temperature of the solutions alters through heating up while in the instrument, it is advisable either to adopt a standard reading procedure or to warm all the solutions to a suitable temperature beforehand.

Three other practical points may be worth mentioning. Acetone is one of the many substances which give the Jaffé reaction, and it should not be used for drying glassware[7]. Standard creatinine zinc chloride solutions in $N/10$ hydrochloric acid will not keep for more than a few weeks at room temperature[8]: they can be kept under toluene in the refrigerator. Finally, the reagent proportions suggested by Bonsnes and Taussky have the advantage that the alkaline picrate solution does not form a precipitate, and will keep for longer in the mixed form.

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Dec. 18.

[1] Bonsnes, R. W., and Taussky, H. H., *J. Biol. Chem.*, **158**, 581 (1945).
[2] Hawk, P. B., Oser, B. L., and Summerson, W. H., "Practical Physiological Chemistry", 472 (Philadelphia: Blakiston, 1947).
[3] Garner, R. J., *Nature*, **170**, 460 (1952).
[4] Peters, J. H., *J. Biol. Chem.*, **146**, 179 (1942).
[5] Gibb, T. R. P., "Optical Methods of Chemical Analysis", 74 (New York: McGraw-Hill, 1942).
[6] Borsook, H., and Dubnoff, J. W., *J. Biol. Chem.*, **132**, 559 (1940).
[7] Jaffé, M., *Z. physiol. Chem.*, **10**, 391 (1886).
[8] Borsook, H., *J. Biol. Chem.*, **110**, 481 (1935).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Sunday, June 21

International Haemophilia Society (at the Seymour Hall, Seymour Place, London, W.1), at 2 p.m.—General Meeting.*

Monday, June 22

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting.

British Society for the History of Science (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Dr. Philip George: "The Scientific Movement and the Development of Chemistry in England from 1664–5 until 1750, as seen in the papers published in the *Philosophical Transactions* of the Royal Society".

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. Karl K. Darrow: "Solid-State Electronics".* (Further Lectures on June 23, 25 and 26.)

Tuesday, June 23

Society for Endocrinology (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 5.30 p.m.—Dr. Charles Huggins (Chicago): "The Prostatic Glands as Targets for Steroids".*

Thursday, June 25

Royal Scottish Forestry Society (in the Meeting Pavilion, Room B, Royal Highland Show, Alloa), at 2 p.m.—Mr. Frank Oliver: "The Gale of 31st January 1953—an Appreciation of the Situation".

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Prof. J. H. Quastel, F.R.S.: "The Action of Drugs on Enzyme Systems".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Biochemist (honours science graduate) primarily for research duties in the Geriatric Department of the Sunderland Hospital Group, carried out mainly at the Sunderland General Hospital—The Senior Administrative Medical Officer, Newcastle Regional Hospital Board, Blythswood South, Osborne Road, Newcastle-upon-Tyne 3 (June 27).

Demonstrators (2) in Inorganic Chemistry—The Registrar, King's College, Newcastle-upon-Tyne (June 27).

Principal of Croydon Polytechnic—The Chief Education Officer, Education Office, Katharine Street, Croydon, Surrey (June 27).

Senior Lecturer to teach Metallurgy, a Lecturer to teach Inorganic and Physical Chemistry, and a Lecturer to teach all branches of Physics, at the College of Commerce and Technology—The Director of Education, Leopold Street, Sheffield 1 (June 27).

Assistant (Experimental Officer grade) in the Pathology Department, for routine work on selection and indexing of fruit stocks for virus infection and assistance with experimental work on plant virus diseases—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee (June 30).

Assistant Principals (2) at the Nigerian College of Arts, Science and Technology—The Secretary, Advisory Committee on Colonial Colleges, 15 Victoria Street, London, S.W.1 (June 30).

Lecturer in Applied Chemistry (with honours degree or equivalent, with teaching and industrial or research experience)—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (June 30).

Lecturer in Physics, and a Lecturer in Genetics, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 30).

Assistant Lecturer to teach Chemistry to H.N.C. and A.R.I.C. standard, at the Technical College of Monmouthshire, Crumlin—The Director of Education, County Hall, Newport, Mon. (July 1).

Speech Therapist in charge of the Speech Therapy Clinics—The Clerk of the County Council, County Hall, Newport, I. of W. (July 1).

Assistant Lecturer (Grade III) in Physiology (veterinary)—The Registrar and Secretary, The University, Bristol (July 4).

Director—The Secretary, Hill Farming Research Organization, Moredun Institute, Gilmerton, Edinburgh 9 (July 4).

I.C.I. Research Fellowships in Physics, Chemistry, Metallurgy, Engineering or Geology, or in a subject allied to these—The Registrar, University of Wales, University Registry, Cathays Park, Cardiff (July 4).

Lecturer in Philosophy—The Registrar, King's College, Newcastle-upon-Tyne (July 4).

Metallurgist at the Ministry of Supply, London headquarters, to assist in research and development work on metallic materials for aircraft construction and to progress research contracts with Universities, Research Associations, Materials Manufacturers and Aircraft Constructors—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.245/53A (July 4).

Physical Chemist at a Ministry of Supply Research Establishment near Sevenoaks—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.246/53A (July 4).

Lecturer in Bacteriology at the Royal Infirmary, Glasgow—The Secretary of University Court, The University, Glasgow (July 8).

Assistant Agricultural Economists in the Ministry of Agriculture and Fisheries—The Civil Service Commission, Burlington Gardens, London, W.1, quoting 4219/53 (July 9).

Electrical Engineers in Ministry of Supply Experimental Establishments mainly at Malvern, Farnborough, Christchurch and Sevenoaks, for research, development or design in telecommunications, radar, electronics, instrumentation or light electrical measurements—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.232/53A (July 10).

Junior Lecturer in Applied Pharmacology and Therapeutics—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (July 10).

Director (with university degree in agriculture or horticulture) of the States' Experimental Station—The Secretary, Department of Agriculture, 6 Bond Street, St. Helier, Jersey, C.I. (July 11).

Senior Lecturer in Physics at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15).

Organic Chemist as Research Assistant to the Professor of Medical Chemistry in the John Curtin School of Medical Research, Canberra, for research on the synthesis of new heterocyclic compounds, in particular, pteridines, pyrimidines and pyrazines—The Secretary, London Office of the Australian National University, 27 Russell Square, London, W.C.1 (July 17).

Research Officer (Protein Chemist) (with university honours degree in science with physical—organic—or biochemistry as major subjects and, preferably, research experience in some aspect of protein chemistry) in the Biochemistry Unit of the Wool Textile Research Laboratory, Parksville, Melbourne, to study the chemical composition and reactivity of collagen by application of physical organic or biochemical procedures used in this laboratory for research on wool keratin—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 462/56 (July 18).

Lecturer in Mining (with a university degree in mining and a first-class Colliery Manager's Certificate), and a Demonstrator in Chemical Pathology—The Registrar, The University, Leeds 2 (July 20).

Physicist (honours graduate) to assist in problems related to the treatment of cancer by X-rays, radium and telecobalt—The Secretary and House Governor, Mount Vernon Hospital and Radium Institute, Northwood, Middx (July 25).

Physicist or Metallurgist (Ph.D., with additional research experience, or equivalent qualifications, are essential) in the Division of Tribophysics of the Commonwealth Scientific and Industrial Research Organization, located at the University of Melbourne, to work with its metal physics group—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 37./81 (July 25).

Director (with the status of Professor) of the newly established Dental Research Unit located in the University of the Witwatersrand Oral and Dental Hospital at Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

Senior Lecturer in Geology (specialized either in stratigraphy and palæontology, or in economic or mining geology), at the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

Lecturer in the Department of Chemistry at University College of Fort Hare, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 1).

Lecturer in Prehistory at Auckland University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 31).

Assistant Professor of Micro-anatomy (histology and embryology), and an Assistant Professor of Gross Anatomy, in Dalhousie University, Halifax, Nova Scotia—Prof. R. L. DeC. Saunders, c/o Mrs. MacDougall, Upper Slaughter, Cheltenham (September 7).

Demonstrator in Electrical Engineering—Prof. G. F. Tracy, Electrical Building, University of Toronto, Toronto 5, Ont., Canada.

Head of the Department of Mathematics, Cardiff College of Technology and Commerce—The Director of Education, City Hall, Cardiff.

Lecturer (Grade B) in Chemistry (with postgraduate experience in organic or inorganic chemistry)—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

Lecturer in the Department of Civil Engineering (with a good honours degree; and practical or research experience in Civil Engineering Hydraulics would be an advantage)—The Secretary and Registrar, The University, Southampton.

Lecturer in Mathematics—The Clerk to the Governors, Mid-Essex Technical College, Market Road, Chelmsford.

Medical Research Officer and a Research Entomologist for the Virus Research Unit in Nigeria, for research on arthropods of medical importance, with particular reference to viral and rickettsial diseases—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.117/14/02.

Physiologist (Scientific Officer or Senior Scientific Officer grade) (with a good honours degree in physiology, or an equivalent qualification, and research experience, preferably involving the perfusion of isolated organs) for research on the physiology of lactation—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 53/3.

Professor of Physical Metallurgy—The Head of the Department of Metallurgical Engineering, University of Toronto, Toronto 5, Ont., Canada.

Research Assistant (graduate preferred) in the Department of Inorganic and Physical Chemistry, for the preparation of crystallographic data and the coding of problems for calculations on an electronic computer, and also the actual running of problems through the computer—Prof. E. G. Cox, Chemistry Department, The University, Leeds 2.

Wool Textile Research Council Scholarships (*a*) for work on infra-red spectrometry and (*b*) for work in wool textile technology—The Principal, Technical College, Bradford.